A BEST PRACTICES MODEL FOR IMPLEMENTING SUCCESSFUL ELECTRONIC DISEASE SURVEILLANCE SYSTEMS: INSIGHTS FROM PERU AND AROUND THE GLOBE

by

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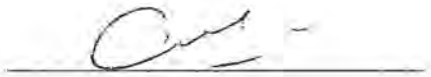

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DEDICATION

I dedicate my dissertation work to my grandmother, Clarita. All my childhood memories are colored by her unconditional love. To my parents, Manuel and Carmen, who lived a life of hard work to give me the opportunity to pursue my dreams. They taught me that with dedication and love everything is possible. And finally I dedicate my work to my soon husband to be, Ravi. Thanks so much for believing in me and holding my hand during this time and for the rest of our lives.

ABSTRACT

Title of Dissertation: Understanding implementation success of electronic disease surveillance systems in Peru: A grounded theory study

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As technology becomes more accessible, many developing countries are turning to implementing electronic systems to enhance their disease surveillance capabilities and move toward complying with the International Health Regulations. The purpose of this study is to contribute to the evidence base of electronic disease surveillance systems implementation in developing countries by building a framework that will identify key elements in this process and serve as guidance to implementers. This study reflects findings associated with three aims: a) a review of the scientific and gray literature on electronic disease surveillance systems implementation experience; b) an expert consensus workshop on the same topic; and c) the development of a disease surveillance system model using the qualitative approach of Grounded Theory and informed by qualitative data provided by 34 surveillance stakeholders in Peru. The researcher triangulated findings from each of the three aims to validate, complement and generate a revised model. She developed this model based on the confluence of several factors at different levels. The model indicated the institutional administrative level as a starting point for

disease surveillance system implementation. High-level administrators' commitment to implement and sustain the surveillance system by enacting legislation and allocating resources proved to be key to the successful implementation of such a system. National and regional surveillance teams performed the critical functions of disease surveillance-related training, monitoring, supervision, and feedback. The teams addressed the critical needs of surveillance staff, contributing to the motivation of reporting staff and ensuring high performing staff at surveillance sites. Finally, surveillance staff found it motivating to observe the outcomes of their work, including appreciating the usefulness of the data they reported in guiding decision-making. As a result of their reporting efforts, they saw disease outbreaks averted and preventive actions implemented in an effort to improve the health status of the population. The positive impact of disease surveillance on population health served as a primary motivator for surveillance staff and stakeholders to continue their work. The model as a result of this study will potentially serve as a useful tool in facilitating the implementation of electronic disease surveillance systems in country contexts similar to that of Peru.

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CHAPTER 1: BACKGROUND AND LITERATURE REVIEW

The severe acute respiratory syndrome (SARS) epidemic and the influenza A (H1N1) pandemic have reinforced the value of disease surveillance worldwide (9; 35). Subsequent to the events surrounding SARS, the public health community in developed countries made greater efforts to improve public health capabilities, investing increasingly large sums of money to enhance their existing surveillance systems and to develop complementary early outbreak detection tools (7; 12; 71; 82).

Developing countries not only have been the source of new diseases, but also the majority of the global infectious disease burden remains concentrated among the poorest 20% of the world's population (10; 34; 45). Unfortunately due to competing priorities, many of these countries have neglected disease surveillance, and thus have invested little in building an infrastructure to support it (89). Surveillance research in resource limited settings has typically been focused on specific diseases of interest to funders and implemented through laboratory-based projects of limited duration (14). An Institute of Medicine (IOM) workshop summary entitled, "Achieving Sustainable Global Capacity for Surveillance and Response for Zoonotic Diseases", recognized the need to build capacity for sustainable, long term surveillance and response in countries with a high likelihood of emerging infections (8). Workshop participants acknowledged the existence of current disease surveillance networks and reporting systems worldwide. They noted the great effort required to enable these systems to continually distribute timely, high quality information (8). Such efforts have included the integration of surveillance and health information systems (74).

Electronic surveillance systems are important tools that are recognized for their increasing importance in disease detection and monitoring, improved quality and effectiveness of data collection, and data analysis and information dissemination (75). Experience has shown that despite potential benefits, not all implementation efforts introducing new technologies in healthcare settings are successfully adopted (79). Failure occurs in up to sixty to seventy percent of technology implementation efforts, leading to a substantial waste in investment (3). Moreover, a dearth of literature exists regarding the experience of implementing surveillance systems in resource-limited settings (20). There are few evaluative case studies from which one could estimate the success and failure rates of public health surveillance systems (59). While some evidence exists on sophisticated disease surveillance systems implemented in developed countries (11; 43; 92), such experiences with disease surveillance systems cannot be directly generalized to the developing world due to differences in demographic, sociological, and cultural characteristics; the political and organizational context; and resource availability including technology (41; 64; 75). Furthermore, the guidelines developed by the Centers for Disease Control and Prevention (CDC) for *Evaluating Public Health Surveillance Systems,* while offering a useful resource that describes the performance attributes of a good surveillance system, fall short in offering direction on weighing the importance of these attributes. More importantly, these guidelines do not provide indicators useful in operationalizing such attributes around implementation.

Due to the limited availability of published literature on the implementation of electronic disease surveillance systems in developing countries, the researcher developed a systematic review of the literature to identify the potential implementation attributes

associated with health-related programs in developing countries. The decision to use health-related programs as a proxy to diseases surveillance system was based on the fact that disease surveillance systems are a key component of the public health programs of a country or an organization (17). Therefore, the principles applied to the planning and implementation of diseases surveillance systems are similar to those used for health-related programs (66).

The methodology of this literature review is described in Appendix A. A total of 32 studies were identified for inclusion in this systematic review from a combined pool of 9,785 abstracts (i.e., 888 abstracts from the initial search and 8,897 abstracts from the second search). A total of 9,695 abstracts were excluded from initial review due to their lack of relevance or inability to meet established inclusion criteria. To be included in the systematic review, studies had to meet the following criteria: a) be indexed to one of the selected information sources, b) be written in English, c) be focused on a developing country(ies), and d) must have addressed the implementation of a specific health-related program. There were no restrictions on date of publication, specific research methods, focus of intervention, or outcome measure(s) addressed. Opinion or commentary manuscripts were excluded only if they did not meet the four criteria outlined above. From the abstract review, a total of 90 manuscripts were selected for full-text review. A data extraction instrument developed for this study (Appendix B) was applied to all 90 manuscripts, leading to the exclusion of 58 manuscripts.

The primary outcomes of interest in the review were the potential factors affecting the implementation of health-related programs in developing countries. Although this literature review did not specifically address disease surveillance systems implementation

(only three papers focused on disease surveillance (46; 69; 91)), the researcher believed that these findings might still be applicable in initially guiding this research.

The researchers independently reviewed the 32 selected studies and grouped their salient findings into primary categories and subcategories. The four primary categories that emerged from the review included: Program Design, Accountability and Leadership, Engagement, and the Environment (See Figure 1). Each of the four categories identified will be discussed below, and the detail of the each primary category is described in Appendixes C, D, E, and F.

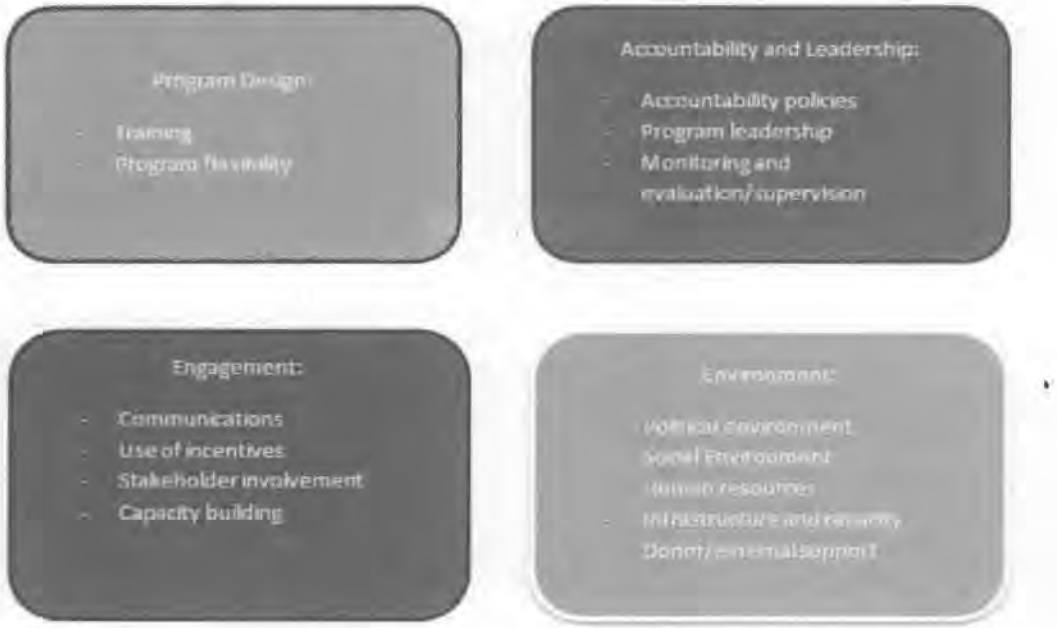

Figure 1: Concepts identified in a systematic literature review on factors associated with successful implementation of health-related programs in developing countries.

Program design

The program design category included potential implementation factors that directly addressed the design or structure of each health program. Within this category the researcher included two sub-categories, which were *training*, and *program flexibility*.

The researcher learned that the authors of 12 papers who addressed program design considered *training* to be an important factor in health program implementation. The format of a given training session was deemed important by the authors of two papers. Specifically, several brief formal training sessions for health workers were found to be more effective than a single multi-day training session (18). A cascade approach to training was preferred (18), and small-group training discussions were favored over large gatherings (28). Several authors emphasized the preparation and provision of training manuals, guidelines, and other technical documents to participants (13; 25; 28; 57; 70). The provision of these materials were believed to be useful in building trust in the program (28) and aided in the adaptation of larger programs to local conditions (13; 57; 70). Some programs leveraged existing mass communication for their training activities in a given country or region in an effort to reduce cost and broaden exposure (1; 22). Of the 32 papers reviewed, the authors of four papers reported efforts to measure the association with or influence of training on health program outcomes. Findings associated with one study revealed improved performance (related to likelihood of missing data in an information system) as a consequence of training (36), while findings from other three studies identified no significant relationship between training and desired program outcomes (e.g., reduced mortality, outpatient utilization) (2; 13; 48).

Program flexibility was a notable design issue, especially when applied to information systems. Some systems integrated local data into a larger system to provide an understanding of risk and change (27), while two other systems allowed for local adaptation of the software and available data to accommodate need (36; 50). Still other

systems were designed to fit the medical environment (57), or were built using a staged "bottoms-up" approach based on local need (31).

Another aspect of program flexibility related to strategies for engaging health-related program beneficiaries. In some programs, interventions were packaged differently in an effort to tailor them to the target audience (18), while others allowed for flexibility by bringing the program into local communities and complementing local infrastructure (83).

Accountability and Leadership

The health program-related literature that was categorized as accountability and leadership included potential implementation factors that addressed leadership and accountability in the areas of process and performance. The researcher identified three subcategories that included *accountability policies, program leadership, and monitoring & evaluation/supervision.*

The authors of seven papers highlighted the presence or absence of *accountability policies* as potential factors for consideration in program implementation. They cited a need for governmental legal and regulatory support for health-related program implementation as important (39). Health programs suffer if they lack government capacity to support accountability, lack authority to impose penalties on poor performers, or organizations fail to address the program in public health policies and recommendations (46; 91).

The authors of ten papers addressed the importance of *leadership* as a potential factor in program implementation. While the authors of two papers discussed the need for

well-placed individuals to serve as program coordinators or gatekeepers (31; 103), others focused their attention on the need for active leadership at all program levels, including the governmental level (6; 25; 26; 44).

The need for adequate *supervision* in overseeing all aspects of a health program was addressed by the authors of eight papers (2; 13; 25; 39; 40; 57; 69; 106). Likewise, the need for a formal program monitoring and evaluation system, as well as a responsive adaptation process to feedback received from the monitoring and evaluation was also addressed (2; 40; 57). As there was no single *monitoring and evaluation* process recommended for all programs, variation in the processes occurred among the programs . What was consistent was the need to limit the number of core indicators included in the evaluation in an effort to avoid overwhelming the predominantly low-resourced settings (13; 18; 31; 50). However, one risk of limiting the number of core evaluation indicators was that they could be the "wrong indicators," that did not measure program success or proved to be unattainable indicators given program resources and setting (28; 78).

Engagement

The health-related program category of engagement included potential implementation factors that addressed how programs connected with their targeted audiences and other key stakeholders. The researcher identified four subcategories related to engagement that included *communication, use of incentives, stakeholder involvement, and building local capacity.*

Communication as a key concept surfaced in five of the papers reviewed as, a potential implementation factor. Internally-focused communication factors related to feedback mechanisms in providing staff with an understanding of their performance (69),

improving referral and information feedback using simple tools (60), and the need to enhance the flow of communication among the various organizational levels (e.g. program, local, regional, national government) (25; 78; 91).

The *use (or lack of) incentives* as a mechanism to engage both target program beneficiaries such as community members in regions where the program was implemented as well as program staff was addressed by authors of five papers. Two of the programs that employed financial incentives for both staff and beneficiaries' for program participation reported negative findings (60; 78), specifically related to the implementation of a tuberculosis program in each of two developing countries. An assessment of the tuberculosis program found no direct relationship between financial incentives and improved diagnosis or treatment (60). In one program that targeted tuberculosis in Nigeria, the use of financial incentives was counterproductive in that it established an unsustainable precedent for beneficiaries' participation (78). The use of non-financial incentives (e.g., food) for participation was identified as an important element in three programs with no negative results reported (40; 83;106). In one program, access to diagnostic facilities and educational programming was used as incentives to encourage staff participation (57).

Engaging key stakeholder groups early and frequently was cited as an important strategy for successful program implementation (2; 6; 60). Interactive engagement with key stakeholder groups led to positive outcomes such as skill development (51; 54), local ownership of key processes (51), motivated workers (54), and improvement modifications to the intervention itself (29). One major stakeholder group cited as a primary target for engagement was the Ministry of Health (MOH) in each country where

a health program was implemented. Creating a role for the MOH in program implementation appeared to contribute to a sense of program ownership, or strong government commitment (1; 25; 54), a positive attitude among various parties (31); and ultimately a positive impact on policy implementation (26; 54).

Developing local capacity can prove to be fruitful in terms of program output and outcomes. Evidence suggests that developing local capacity can lead to improved quality of care (2; 83), empowerment of local people and communities (27), local ownership of the program (51), resource and data sharing (31), and decreased dependence on external services (83).

Environment

The environment category included attributes of the operating environment (e.g., local, regional, national) of the program to be implemented. It is noteworthy that while the program may have some influence over its operating environment, some attributes are beyond its control. The researcher identified five subcategories of environmental influences that included *political environment, social environment, human resources, existing infrastructure and capacity, and donor/external support*, each of which will be explained below.

The *political environment* was an environmental factor in health program implementation that was addressed by the authors of ten papers. Five authors touted the importance of local and national political support in the coordination of program efforts (2; 4; 25; 44; 63). Other authors outlined requirements for gaining political support that included, for example, positive program results (4), timely data reporting (91), and international partnerships (78). In terms of political environment, several authors

highlighted the challenges posed by fluidity of a political support base and government stability (106), actual emergencies that captured government attention (57), and competing national priorities (106).

The *social environment* as an environmental factor in program implementation was addressed in seven papers. Social issues within developing countries might foster mistrust between staff, the program, and targeted beneficiaries (22; 106). The authors of three papers addressed the social atmosphere in which the program operated (27; 40; 50) and how staff adopted a caring ethos that permeated not only a direct care relationship, but also the local community in general (50).

The availability or skill level of *human resources* to deliver a health-related program was addressed in ten papers. The most cited challenge to human resources for programs in these developing countries was staff absenteeism (4) and turnover (4; 13; 18; 28; 37; 51). Human resource capacity at the national and sub-national levels was identified as an important constraint by the authors of four papers (6; 27; 44; 50). On a micro level, the presence of worker mistrust, attitude of helplessness and lack of motivation was also cited as personnel issues that hindered program delivery (28).

Operating a new program using existing *infrastructure and local capacity* could lead to challenges during the stages of both health program design and implementation. The authors of two papers addressed the importance of an existing health care structure in program implementation (22; 40). Depending on the program, a basic level of infrastructure was critical, including such elements as roads and transport for supplies; telephones; electricity; and available computers (22; 46; 57).

The authors of four papers specifically addressed the role of *donors and external support* in program implementation (4; 6; 40; 57). Key attributes of program support that these authors identified included sufficient and flexible financing and hands-on support by partner agencies (6).

Attributes related specifically to disease surveillance systems

The authors of three papers described their personal experiences with disease surveillance programs. They identified four factors important to surveillance program design: a) simplicity of data entry (91); b) simplicity in case definitions (syndromic approach) (91); c) training in data analysis (91); and d) data quality through standardization of data at the national level (91).

Program acceptability was unfavorably affected by several factors including a lack of connection between the program and response and control measures (46; 91), a perception of the program not being interoperable within a routine system (91), and a lack of accountability for low performance (46; 91). Increased surveillance program acceptability at a national level was associated with the timely reception of data (91). Close monitoring was considered key in the implementation process (69) as was the flexibility of the surveillance system in adapting to feedback from surveillance stakeholders (69).

Among the engagement factors identified by the researchers in this review were an improvement in feedback and communication at all levels and among all surveillance actors (91), broad-based training for reporting staff (46), and a commitment of resources to afford a better response (69). Similarly, poor dissemination of data, and lack of feedback to surveillance staff on their performance (69) were suspected reasons for lack

of staff motivation. Additional environmental factors included the availability of resources at the surveillance sites such as phones and electricity (46).

In summary, a systematic review of the research literature related to health program implementation revealed that program design, accountability and leadership, target audience and stakeholder engagement, and environmental factors were important considerations in the implementation of such programs in developing countries. Training and flexibility were that emerged as program design issues. Germane to the area of accountability and leadership were accountability policies, leadership, supervision, and the need to address monitoring and evaluation processes such as the identification of indicators to be evaluated. Key considerations in engaging target audiences were issues of communication, incentives use, stakeholder involvement, and local capacity building. Related to the environment in which the health-related program was implemented, the political and social environment were key considerations as were the availability and skills of human resources, existing infrastructure and capacity, and the role of donor financing and need for external hands-on sources of support (See Figure 1).

Although factors identified in the literature review might provide initial guidance, it was evident that a need existed for research on factors affecting the successful implementation of disease surveillance programs in developing countries specifically (20; 64). Therefore, the researcher developed this study to address the knowledge gap in this area. This work was structured around three aims: a) to expand the literature review by searching the gray literature in order to identify implementation factors associated specifically with electronic disease surveillance systems in developing countries; b) to convene experts in disease surveillance and related areas in an effort to define the

purpose, operation, and the factors related to successful implementation of electronic disease surveillance systems; and c) to develop an initial framework informed by Grounded Theory methodology based on the collection and analysis of primary research data related to program implementation from electronic disease surveillance programs in Peru.

The initial framework developed in aim #3 was revised after triangulating data collected in the previously described systematic literature review, the results of the gray literature search (aim #1), and the conclusions of the expert consensus workshop (aim #2).

The revised model provides an understanding of all of the components of a surveillance system, key stakeholders, and activities that must be performed and identifies the barriers to success in global settings that will enable public health officials to design more effective disease surveillance systems. Effective disease surveillance systems will better meet the needs of developing countries and the several governmental and non-governmental organizations that fund these initiatives (e.g., Department of Defense Global Emerging Infections Surveillance and Response System (GEIS), and The Bill & Melinda Gates Foundation). Such surveillance systems will lead to more effective use of resources (19), improved disease surveillance, and ultimately the improved health status of the population.

CHAPTER 2: MATERIALS AND METHODS

As addressed in the previous chapter, this study was structured around the development of three aims. Findings from a systematic literature review presented in the background chapter indicated the limited literature available to guide the implementation of electronic disease surveillance systems in developing countries. Therefore, the first aim involved expanding the research literature review to include the grey literature in order to identify such factors. To complement this effort, the researcher organized a workshop that convened experts in the field of electronic disease surveillance implementation to reach consensus on surveillance implementation factors.

Aims #1 and #2 provided the foundation for aim #3, ithe outcome of which was the development of a model or framework for the successful implementation of electronic disease surveillance systems in developing countries based on primary data collection in Peru. The model that emerged from the data collected in Peru was then triangulated with data from three additional data collection strategies used in this research: systematic literature review, grey literature review, and expert consensus workshop. The triangulation of data led to the creation of a new refined model that provided a more comprehensive insight to implementers of such systems in resource constrained settings.

Aim #1 – To expand a preliminary literature review by searching in the gray literature for factors associated with the implementation of electronic disease surveillance systems in developing countries.

The first aim expanded the preliminary systematic review of the literature by including gray literature sources. The gray literature refers to publications that are not indexed in traditional biomedical and nursing databases and are not controlled by commercial publishing interests. It is a gray literature that is comprised of documents issued by government, academia, and business and industry, such as newsletters, reports, working papers, theses, dissertations, government documents, bulletins, fact sheets and conference proceedings (95). The Internet was used as the major source of gray literature in this topic.

The additional gray literature search was necessary to identify specific documents that described successful implementation practices for electronic disease surveillance systems in developing countries. In the development of aim #1, the researcher initially searched for documents on Popline, NTIS, ERIC, New York Academy of Medicine (NYAM), Worldcat, and Google Scholar. The search was conducted in January 2012 and periodically repeated during a one-year period from January to December 2012 to ensure the capture of any newly available documents. No starting date limits were used in this search of the resources mentioned above.

The search strategy and results are summarized in Figure 2. A different search strategy was developed for each of the resources. The investigator used a broader search strategy for ERIC, POPLINE and NYAM to ensure all publications related to the topic were included; these resources revealed very limited number of results when specific key words was used ("electronic disease surveillance"). On the other hand, when using Google Scholar and WorldCat, the investigator applied a narrower search strategy using the terms "electronic disease surveillance" AND "developing countries" because of the

large volume of results obtained when using those specific key works. The researcher sought consultation with experts on disease surveillance from the Pan American Health Organization (PAHO). Recommendations by PAHO led to retrieving references on the World Health Organization website, including their Integrated Disease Surveillance bulletin, the Weekly Epidemiological Record, and the African Regional Office. Lastly, the investigator reviewed references cited in all of the publications selected and applied the same inclusion criteria described to those references. Documents retrieved were included in the review if they met the following criteria: a) the surveillance system described was electronic; b) the surveillance system functioned in a "developing country" or a "developing setting" as defined by the International Monetary Fund's World Economic Outlook Report, October 2009; and c) the source described surveillance system inputs, activities, outputs or outcomes, or an evaluation of the implementation process.

Once all the publications were selected using the inclusion criteria, key dimensions of the system's implementation were documented qualitatively. Basic qualitative coding methodology was applied to the documented dimensions in an effort to identify key themes used in reporting the findings. The researcher identified themes after completion of the review, and a table was developed to summarize the findings in each publication included in this review. As presented in Appendix J, the format of the table included: 1) reference, 2) country/external support, 3) details of system and tool, 4) study design and analysis, 5) factors observed to contribute (to successful implementation), and 6) challenges and needs.

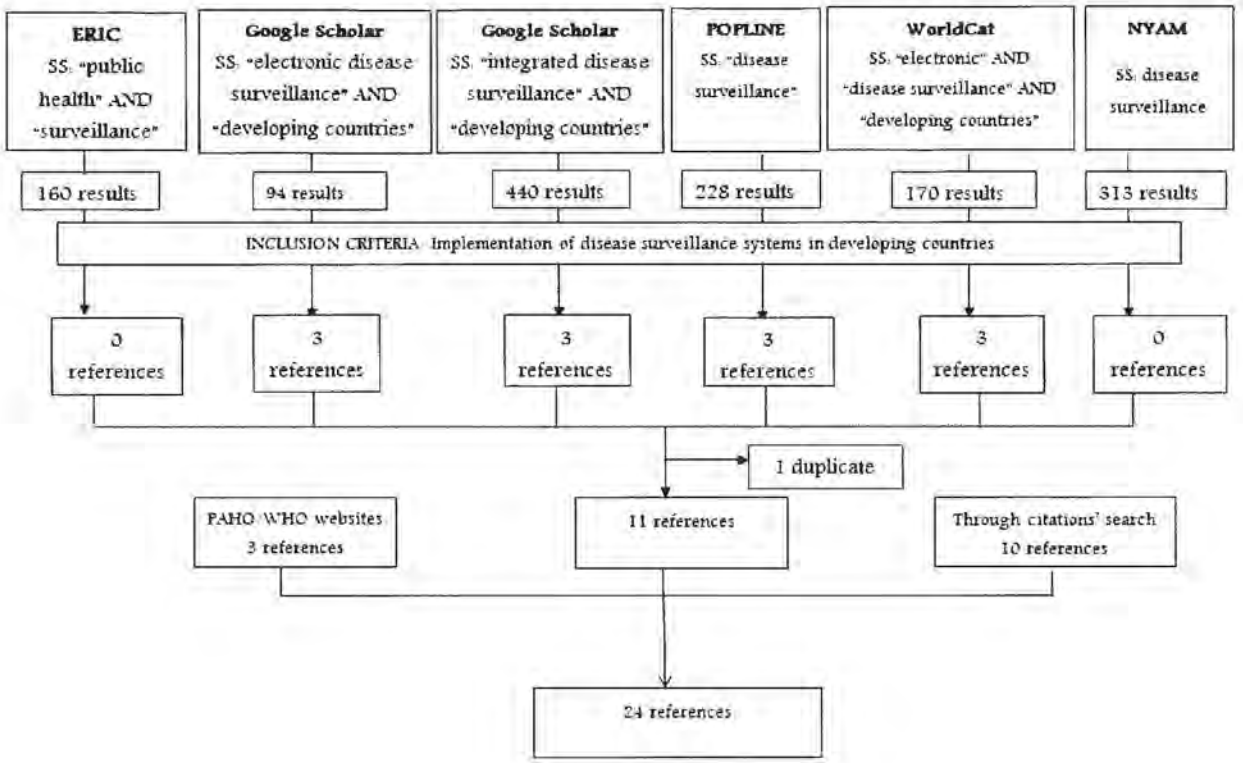

Figure 2: Strategy for the inclusion of literature for electronic disease surveillance implementation on developing countries.

Aim #2 – To convene experts in disease surveillance and related areas in an effort to define the purpose, operation, and the factors related to successful implementation of electronic disease surveillance systems.

Aim #2 was developed to complement and compare information acquired through the previous literature reviews performed. In conjunction with these two methodologies, the expert consensus workshop was intended to provide the foundation for the primary data collection in Peru. Data from Peru provided an initial model to understand the implementation process of electronic disease surveillance systems in a low resource country. Using the findings from the expert workshop consensus process and the literature review, the researcher developed the interview tool for aim #3. Furthermore, the expert consensus workshop findings and conclusions served as one of the information sources used to triangulate and refine the model.

On February 22, 2012, the researcher held an expert consensus workshop titled, "Electronic Disease Surveillance Systems Implementation in Developing Countries," with the support of the Armed Forces Health Surveillance Center (AFHSC). The workshop hosted a panel of 15 subject matter experts in the field of electronic disease surveillance systems who discussed factors related to the successful implementation of such systems in resource-limited settings. Workshop attendees were invited based on their expertise in the area of disease surveillance implementation and public health informatics, and their experience in resource limited settings. Due to budget constraints, the participant selection was focused on experts working in the Washington, DC area. A list of the participants and their positions at the time of the workshop is presented as Appendix G.

The planning phase for this workshop involved members of the researcher's thesis advisory committee with expertise on this field. Each member provided a list of potential participants for the workshop and the final list of participants to be invited was agreed upon through email. The researcher held a meeting with her committee members to develop the agenda of the meeting, and identified the need for facilitators. Several committee members volunteered to be the facilitators for the discussion sessions. Two participants agreed to be note takers for the discussion sessions. The logistics for this meeting was supported by the AFHSC.

Workshop attendees addressed the lack of literature (published and gray) in this topical area and a need for guidance on improving surveillance capabilities. The questions of primary focus included: a) what is the definition of electronic disease surveillance? In order for a system to be considered electronic, how does technology need to be included in the process of data collection, analysis and feedback?; b) Are there stages or phases in the process of implementation of an electronic disease surveillance system in a developing country? If so, describe each implementation stage or phase, successful implementation milestones for each stage or phase, and identify the performance attributes to be prioritized and the indicators to monitor such attributes; c) What are the key factors (e.g., technical considerations, surveillance system structure, core and support surveillance functions, surveillance quality, financial considerations, political considerations, ethical and cultural considerations, organizational and workforce determinants) related to a successful implementation of an electronic surveillance system in a developing country?

The desired outcome for this expert workshop was the development of consensus definitions or descriptions of concepts relevant to electronic disease surveillance purpose, operation, performance, and implementation in developing countries. In order to provide context for the conversation, the researcher prepared a comprehensive review of the gray literature distributed prior to the in-person meeting held in Washington, D.C. The researcher led the one-day workshop, which was initiated by a presentation by one of the participants on defining a public health surveillance system and its components. The researcher then presented a synthesis of the systematic review of literature previously conducted that addressed the implementation experience of developing countries regarding disease surveillance systems.

Following the initial presentations, the researcher charged the workshop attendees with reaching a common vision of electronic disease surveillance systems and agreeing on a definition of electronic disease surveillance systems. Participants were assigned to one of two groups tasked with responding to one of the two following questions: a) what are the factors related to a successful implementation of electronic surveillance systems in resource-limited settings?; and b) What is the process for planning the implementation of such systems?

Two sessions of two hours each were dedicated to each of the group discussions. After every session, all of the workshop participants re-convened as a large group to present their conclusions to each other, discuss the conclusions, and ultimately reach consensus about the conclusions they had discussed. Every session had a facilitator and a note-taker. The facilitators led the group discussions and both authored a final summary of the sessions. All of the conversations were audio-recorded. The researcher received the

summaries of each session, and affirmed the summarized information by listening to the session audio-recordings.

The researcher developed an initial document summarizing the consensus reached at the workshop around the questions described earlier and emailed the draft document to all participants with a request for feedback. After incorporating all feedback into the initial document, she e-mailed the final revised document to all workshop participants.

Aim #3 – To develop an initial framework, informed by Grounded Theory methodology and using primary research data, related to the implementation of electronic disease surveillance programs in Peru.

The need to focus on the process of implementing electronic disease surveillance systems, described in the Introduction chapter, warranted a qualitative research approach. The researcher's plan to focus on the processes and context to better understand the factors related to successful electronic disease surveillance implementation, and the need for a framework to explain the implementation process pointed to Grounded Theory as the most suitable methodology for this study.

Grounded Theory

Grounded theory is a qualitative research methodology that was developed and first described by Glaser and Strauss in 1967. The methodology involves both describing and explaining the social system under study, and consequently generating an explanatory model based on data collected from the social system (42; 65). Grounded theory utilizes in-depth, open-ended interviews as a primary qualitative data collection strategy; and constant comparison in the analysis of data, including identifying the codes, concepts, and categories that emerge from the data based on participants' direct

experiences with, in this case, disease surveillance. The ultimate goal of Grounded Theory is to inductively build a model or theory that emerges from data rather than from preexisting hypotheses or theories (33; 68). The underlying assumption of grounded theory is that people construct their realities from the symbols around them, and thus make sense of and order their social world (24; 42).

Grounded theory uses systematic data collection and analysis procedures that, when used appropriately, contribute to a credible, rigorous study. This methodology requires theoretical sensitivity and the use of theoretical sampling (21; 65). Theoretical sensitivity relates to the ability of the researcher to gain insight into (21; 65) and understand and give meaning to data collected in order to detect what is relevant to the research. For instance, if the topic upon consideration is implementation of electronic disease surveillance systems in Peru, having theoretical sensitivity would mean the researcher has an understanding of this process due, for example, to previous professional experience that involved leading the implementation of such systems, or by having reviewed the literature on this topic. The researcher has gained theoretical sensitivity as a consequence of her professional experience in Peru related to disease surveillance.

Theoretical sampling refers to the selection of interviewees based on the researcher's ongoing analysis of the qualitative data the researcher has collected (21; 65; 68). In this study, data analysis began with the first interview and continued through the course of data collection. As the researcher gained insight into the implementation of electronic disease surveillance systems in Peru, she based further decisions about participants to be interviewed on her ideas and theories that emerged from the data she had collected and analyzed. In other words, she selected participants in an effort to assist

her in clarifying or confirming emergent research findings. For instance, if during an interview the researcher learned that a system was implemented through a partnership with another organization, she planned to sample potential interview participants from that organization. This type of sampling methodology also meant that the researcher included more participants at the reporting staff level to confirm relationships that emerged from the interviews. She learned, for example, that the surveillance staff's motivation was increased by their observation that important decisions were made in their organization based on the data they had collected and reported.

Peru as an ideal country to pursue this research

The researcher selected Peru for this study based in large part on the country's rich source of data regarding disease surveillance systems. Having worked in this country in disease surveillance, the researcher had previous knowledge of electronic disease surveillance systems functioning within different institutions (MOH and Armed Forces) with both successful and unsuccessful experiences. Furthermore, the researcher had access to potential gatekeepers that made it possible to obtain the required administrative support to conduct this work. The researcher also was a native Spanish speaker, which allowed her to conduct the interviews in the participants' language.

Data collection

Data collection related to aim #3 was approved by the USUHS Human Research Ethics Committee. In addition, the investigator obtained letters of support from the Peruvian MOH and Armed Forces in an effort to facilitate the data collection process.

The inclusion criteria for this study included male and female stakeholders in an electronic disease surveillance system at four levels: the institutional administrative level, the technical assistance level, the national and regional disease surveillance team level, and the reporting staff level in Peru who voluntarily consented to participate. Stakeholders were 21 years or older and worked or had worked at one time on an electronic disease surveillance system that was, at the time of the interviews, functioning for at least one year and that collected information on human infectious diseases for which notification was mandated in Peru. Exclusion criteria for the study included stakeholders associated with electronic disease surveillance systems that did not collect information on their monitoring and evaluation activities related to disease surveillance, or who were affiliated with systems that had been functioning less than one year, that primarily collected data on non-notifiable diseases or that was set up for research purposes only.

Description of surveillance systems studied

The researcher focused data collection on three ongoing electronic disease surveillance systems in Peru that had functioned for at least one year prior to data collection and that collected information on monitoring and evaluation activities related to disease surveillance. The researcher collected data on each of three systems, one in the Peruvian Navy (Alerta DISAMAR), one in the Peruvian Army (Vigila COSALE), and one in the Ministry of Helath (MOH Sentinel Surveillance System). These three systems were purposively selected to capture similarities and differences in implementing national disease surveillance systems in military and civilian environments. These national institutions had a need to implement such systems. Furthermore, the surveillance systems analyzed in the military were the only systems in place in each of their organization

(Peruvian Army and Navy), while the MOH was a sentinel surveillance and complementary system. The three systems had units that reflected high performing surveillance activities and others with low performance reporting rates. The characteristics of these systems provided an ideal setting for conducting this study; each system will be described below. At the time of this study, Alerta DISAMAR was an innovative electronic, Internet and phone based system used by the Peruvian Navy. The Navy used a comprehensive disease surveillance tool for mandatory disease notification. Personnel associated with the Alerta DISAMAR system collected and analyzed daily and weekly disease reports for forty-five diseases and syndromes, including mandatory diagnoses required by the Peruvian MOH and disease conditions of military relevance. The surveillance process involved surveillance personnel in initially recording individual and grouped disease cases on pre-coded forms. Staff then manually prepared summary tables and entered the data into the Alerta system. Pilot operations began late in 2002, moved into a phased-in strategy in 2004, and finally proceeded to total program implementation in 2005. At the time of this study, Alerta DISAMAR received reports from approximately 121 surveillance units, including those based on ships.

The Peruvian Army implemented a system called Vigila COSALE in 2005 using a tool similar to Alerta DISAMAR. The Peruvian Army had somewhat more extensive surveillance coverage of the country compared to the Navy since it received surveillance data from approximately 153 surveillance sites.

The MOH Influenza Sentinel Surveillance System was an Internet-based sentinel surveillance system that captured weekly information that was recorded daily from two sources: a) outpatient visits made by individuals who were clinically diagnosed with Flu-

like syndrome, and b) hospitalized patients diagnosed with severe acute febrile respiratory syndrome or severe acute respiratory infection. The influenza surveillance system was linked to laboratory diagnoses. The system was implemented in 2005 and received information at its highest demand from 52 surveillance sites across the country.

An electronic research toolkit was developed to facilitate data collection and contribute to the rigor and credibility of the study. The toolkit included the following data collection templates: research log; initial/ongoing/final observations of the country in the context of disease surveillance and interview setting; interview introduction; in-depth interview guide; interview and observation field notes; review of documents template; interview summary; and exit synthesis notes. The tool kit also included a document that listed all of the factors related to the successful implementation of electronic disease surveillance systems identified in findings from the review of the literature and the consensus workshop titled, "Electronic Disease Surveillance Systems Implementation in Developing Countries, as presented in Appendix J and Table 1.

Participant recruitment process

The researcher initially used an email message to contact the person in charge of the implementation of the electronic disease surveillance system in each institution or organization. There were no fliers or public recruitment for the study other than email invitations. If the participant expressed interest, the researcher requested an in-person interview of approximately 60 minutes duration. If the potential participant did not contact the researcher after the first email message was forwarded, the researcher sent a follow-up email after one week of the initial email. If there was no response to the second email, the researcher did not contact that person again. Twenty-percent of the participants

contacted did not respond to the second email. The lack of response may be explained by the researcher not having their current email addresses; the limited capacity of some email accounts which prevented the recipient to receive emails once the inbox is full; or these individuals' limited Internet access.

The researcher initiated the study participant recruiting process using purposive sampling. A purposive sample is one that is selected based on the richness of the information the cases will provide to illuminate the questions under study. There are several strategies for purposive sampling such as snowball sampling, which identifies cases by asking well situated-people for potential participants. These new cases are then asked about new participants that can be recruited, making the 'ball' bigger as new people are asked to join the study (72). The researcher developed a glossary with the definitions of the sampling methodologies used, presented as Appendix M.

The researcher initiated participant recruitment for this study by contacting the head of the Central Disease Surveillance hub at the U.S. Naval Medical Research Unit-6 Peru (NAMRU-6). The NAMRU-6 hub provided technical and financial support to the electronic disease surveillance systems that were implemented in the Peruvian Army, Navy, and Air Force, as well as other countries in Latin America. In NAMRU-6, a person from each Peruvian military organization oversaw the performance of their system and worked in collaboration with NAMRU staff.

The researcher identified a Peruvian Armed Forces representative who had significant experience with the Peruvian disease surveillance system. The researcher then used snowball sampling by asking this individual and other subsequent interviewees to identify leaders and others affiliated with the Armed Forces who had direct experience

with disease surveillance in Peru that she might contact. The researcher also used criterion sampling to select individuals to interview who were affiliated with the MOH and the Armed Forces.

Throughout this study the researcher used the qualitative sampling process of purposive sampling that involved obtaining insights from individuals with direct experience with disease surveillance in the country. Criterion sampling served as one form of purposive sampling that led to the initial inclusion of individuals selected according to criterion developed and articulated by the researcher. She also used snowball sampling, another form of purposive sampling.

Consistent with the qualitative research process (72), after conducting and transcribing the first interview, the researcher initiated data analysis. At that point, she began to use theoretical sampling, which is a purposive sampling process associated with grounded theory that involves the selection of interviewees in response to the researcher's evolving data-based thinking about an emerging model of electronic disease surveillance implementation. Intensity sampling was used to identify participants who had important perspectives and rich experiences with the evolving concepts identified by the researcher. A commonly shared concept of externally provided technical assistance emerged, for example. The researcher then interviewed an individual with extensive experience providing technical assistance during the process of implementing several disease surveillance systems. This interview enabled the researcher to gain additional depth and insight into this particular aspect of surveillance implementation.

At another point in the data analysis process, the researcher had gained insight into many elements of the surveillance implementation process, but recognized a need to

explore these concepts from the perspectives of different stakeholders' who held different roles in the surveillance process. She thus began identifying and interviewing individuals at various levels of surveillance responsibility from the MOH and Armed forces.

Data analysis revealed that technical issues related to surveillance tool characteristics needed to be further explored. She then pursued interviews with engineers involved in developing disease surveillance tools in Peru.

The researcher also recognized that in order to better understand the concept of organizational commitment and leadership; she proposed that the starting point for the emerging surveillance model was individuals involved in Peru's initial disease surveillance implementation efforts. She consequently identified and interviewed these individuals.

The researcher sought to fully explore both the Armed Forces and MOH systems and sought to gain insight from individuals from the organizations that comprised these institutions. She interviewed members of the General Division of Epidemiology (GDE) and Peruvian National Institute of Health (NIH), for example, in order to gain this organization's insight into surveillance. These interviews affirmed the importance of several initial observations based on the data. Surveillance systems began with a need that arose from the organization, personnel who were committed to the surveillance process, played a critical role in the system, a need existed to enhance staff motivation and identify incentives and surveillance efforts had to be coordinated. The researcher realized that she had to explore the concepts of "organizational needs" and the importance of coordination coming from the Armed Forces' perspective in order to ensure saturation of concepts such as this was achieved. She conducted interviews to the

point of perceived data redundancy and affirmed saturation by conducting additional interviews.

The interviews the researcher conducted helped her to differentiate between those surveillance sites with good performance and those that did not perform well. The performance of a site was considered "good" if the interviewee referred to it as such. When the researcher asked about the meaning of "good" performance, participants generally agreed that it was a site with a surveillance reporting rate consistently higher than 80%. Contributions to the differences between good and poor performing sites were staff motivation, staff knowledge and skills, flexibility in surveillance processes, support from site directors, and the presence of teamwork at the site.

At this juncture, the researcher considered it important to confirm these concepts with surveillance staff members at sites that participants perceived to be good and bad. With the collaboration of the national surveillance teams from each institution, she was able to schedule group and individual interviews that involved personnel from the two kinds of sites. Data from these interviews clarified the concept of "awareness of the significance of the disease surveillance tasks" for surveillance staff as well as other health and non-health workers at the surveillance units. Interview data also confirmed that the researcher had reached saturation on the "importance of feedback" concept that enabled the researcher to develop the concept that closed the model: the "value and action" concept.

Surveillance staff repeatedly raised concerns about differences in the situations of staff assigned to surveillance sites outside the capital of Lima compared to those assigned to sites closer to the capital and other major cities. Therefore, the researcher considered it

important to interview a person who had exclusively worked in a geographically remote location to explore site-specific characteristics that had been identified by surveillance staff who experienced working at both large city and remote locations. These interviews were conducted during the latter part of data collection and were used to confirm saturation of the concepts already identified at the surveillance staff level. At a point toward the completion of data collection the researcher believed that the concepts that explained the model were fully developed. However, she confirmed saturation by conducting additional follow-up interviews. This strategy was particularly challenging as study participants were busy professionals. Several attempts to reach two potential participants were unsuccessful. The researcher was able to contact and interview two final participants within the guidelines of the ethics committee and was able to confirm saturation. Figure 3 presents a diagram of the recruiting process.

Interviewing process

The researcher conducted all in-depth, open-ended interviews in person in Peru. Once an individual agreed to participate in an interview, that person and the researcher arranged a time and place to meet. Most interviews were conducted in the individual's workplace in a private office setting to ensure confidentiality. All interviews were audio recorded and conducted in Spanish as the native language of both study participants and the researcher.

Before initiating the interview, the researcher used a template script to describe the purpose of the study. She then showed participants the letter of support from their institution or organization regarding the research study. If the participant agreed to participate in the study, the researcher engaged the participant in an informed consent

process. An informed consent document was shared with the participants (Appendix N), which they signed if they agreed to participate.

The in-depth, open-ended interviews the researcher conducted during the study were audio-recorded with participants' permission and transcribed verbatim by transcriptionists in Peru. Participants were not identifiable to transcriptionists who received recordings labeled with the number of the interview rather than the name of the participant. Transcripts were not linked with participant consent forms to ensure anonymity.

The researcher developed an interview guide for each interview that she tailored to the role of the interviewee and purpose of the interview. A sample interview guide is provided in Appendix H. She also took handwritten notes during each interview. She initiated the interviews by asking participants about: a) reasons the disease surveillance system was implemented by the organization or institution; b) factors or stakeholders that helped the implementation process; c) challenges faced during the implementation process; d) factors that enabled the surveillance system to currently function in their organization or institution; and e) how successful they considered the particular disease surveillance system with which they were affiliated. These questions were used to identify initial domains of information that were transformed into concepts as data collection continued.

Before the end of each interview, the researcher summarized the interviewee's responses and asked them for any additional comments. All in-person interviews were conducted over a three-month period from February 2012 to April 2012 in Peru. The researcher conducted future follow-up conversations with interviewees by telephone if

the interviewee had agreed to further contact by the researcher at the time that the in-person interview was conducted.

Data analysis

In summary, the researcher used the process of Grounded Theory to generate concepts that, in turn, guided sampling, data collection, and analysis (33; 68). She continued to contact potential participants via email (21). Data analysis began soon after the researcher completed the first interview. Transcribed interview data were entered into a qualitative software program, NVivo-9, for the purpose of data management and analysis. The researcher repeatedly reviewed each transcript in its entirety in preparation for the analysis. While the researcher was analyzing the data, she wrote analytical memos that were conceptually labeled (21). She wrote such memos for the purposes of open data exploration and, identifying and developing the properties and dimensions of concepts. Axial coding enabled her to relate concepts to each other, draw diagrams to indicate the relationship between the concepts, and to visualize the initial model. She used selective coding to integrate the developed categories and identify the core variable. An example of the coding process is described as Appendix I.

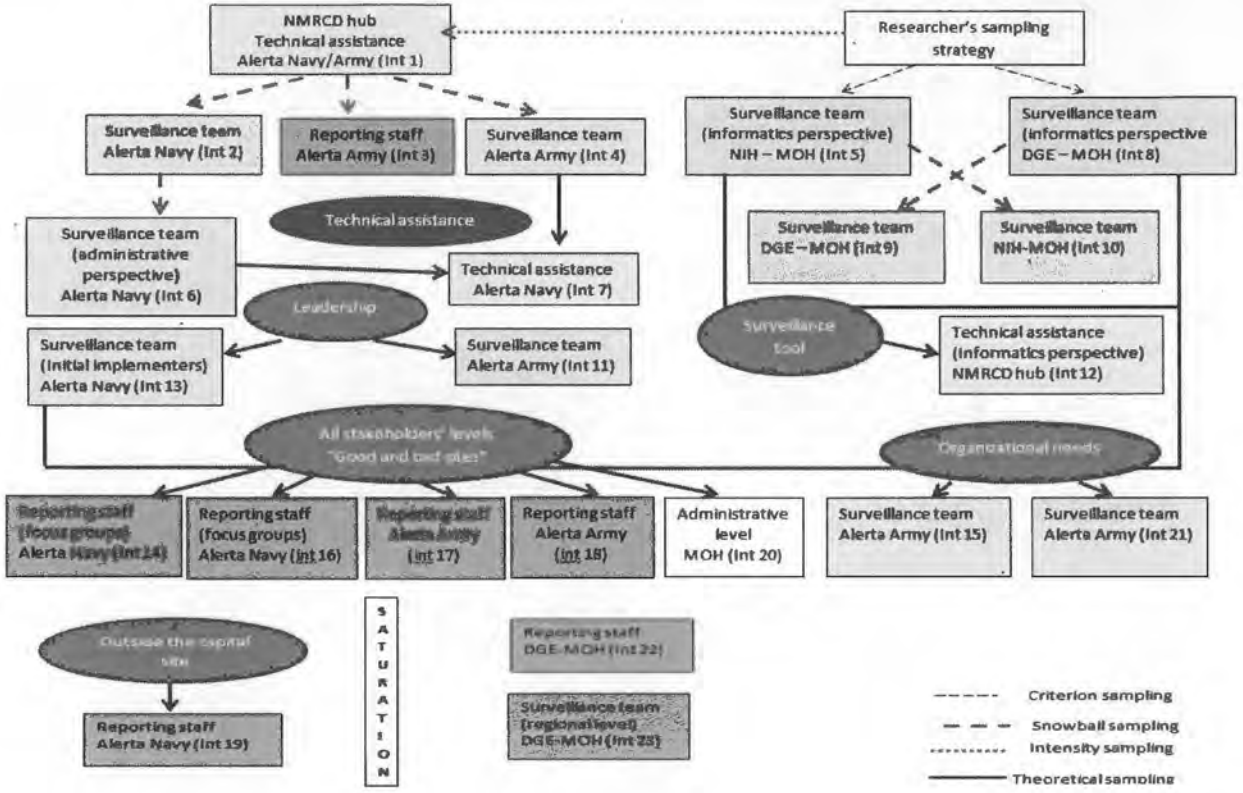

Figure 3: Participant recruiting process.

She differentiated levels of concepts. Higher-level concepts, also called Categories or Themes, encompassed lower level concepts in an effort to reduce the data and better characterize the concept (21). Once the relationships were clearly identified and the concepts were integrated, the researcher outlined the theoretical scheme (21).

Audit trail

The researcher maintained an audit trail that served to document the study and the analytical strategies employed. The audit trail comprised three key documents: a) research log (dated, timed registry of all activity and decision points that occurred during the research process); b) researcher's journal for reflection and reflexivity (dated diary of the researcher's reactions, assumptions and biases related to the data collected and analyzed); and c) analytical memos (previously described). The researcher wrote these documents and, with the exception of the researcher's journal, added them to N-Vivo. The researcher's journal was kept as a separate document, apart from all other documents.

Data triangulation in developing a revised model

The model developed using grounded theory provided a solid foundation to understand the process of implementing of electronic disease surveillance systems in Peru. However, in order to verify the validity of this model and create a revised version of the model that might be generalizable to similar settings external to Peru, the researcher incorporated data triangulation in developing a revised model. The resultant new model was based on the four sources of information associated with this study: the systematic literature review for health-related program implementation in developing countries, the gray literature review for electronic disease surveillance program

implementation in developing countries, the expert consensus workshop on electronic disease surveillance program implementation in developing countries, and the initial model created using Grounded Theory.

Triangulation is defined as "the combination of sources, investigators, methodological approaches, theoretical perspectives, or analytical methods within the same study" (90; 96). Therefore, different types of triangulation exist: theoretical triangulation, investigator triangulation, data triangulation, and methodological triangulation, depending on the choices the researcher makes regarding the elements to be used in the study (104). Triangulation strategies serve two purposes: confirmation of the accuracy of the results by using different approaches or methodologies and assuring completeness in order to provide a more comprehensive understanding of the problem under study (84).

Having used different methodologies for data collection in this study, the researcher used methodological triangulation to revise the initial Peruvian model by confirming the validity of the concepts already identified, and by incorporating new or refined concepts and relationships identified by the other three methodologies. With this process, the researcher aimed to provide a complete picture of the implementation process of electronic disease surveillance systems in developing countries.

The first step in this process was to create tables to show the concepts in the Peruvian model that were identified by the other methodologies used in this study. For the concepts in the model not identified by additional methods, the researcher analyzed and provided reasoning for the finding. Following this analysis, the researcher identified the elements in each of the other three methodologies that were not present in the model.

These concepts were assessed regarding the methodologies that identified them, and were incorporated in the new model if at least two methodologies used in the study addressed their importance. In the case of a concept present in the findings of only one methodology, the researcher assessed supportive evidence for the concept in order to justify its inclusion to the model. In the case of discrepancies in the concepts identified by the different methodologies, the researcher investigated them, and made a note describing the different findings and offering an explanation for their inconsistency.

Finally, the researcher developed recommendations based on this revised model for implementers desiring to establish electronic disease surveillance systems in developing countries, or for those public health professionals desiring to improve and refine their existing disease surveillance systems.

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CHAPTER 3: RESULTS – CONTRIBUTION OF GRAY LITERATURE

The initial systematic review of the scientific literature regarding implementation of health-related programs in developing countries was conducted due to a dearth of literature in the area of electronic disease surveillance systems in developing countries. The review yielded important findings that were useful in initiating a process of understanding the implementation of electronic disease surveillance systems. However, due to characteristics unique to electronic disease surveillance systems (e.g., the use of an electronic tool, electronic reporting processes), the researcher expanded the literature review by conducting a search of the gray literature that specifically addressed the implementation of electronic disease surveillance systems in developing countries.

Using the search strategy discussed in the methodology section, 1,405 publications on the topic were identified using gray literature search tools. 1,393 of which were excluded due to their lack of relevance or failure to meet established inclusion criteria, leaving 12 publications. One duplicated reference identified in the scientific literature was found. The researcher added three publications as a consequence of consultation with experts and 10 more by identifying cited publications within the literature identified. A total of 24 publications were thus identified for inclusion in this review using gray literature website resources, consulting with experts on the topical area, and reviewing the citations included in the publications identified.

Regarding the geographic locations referenced in the 24 publications included in the gray literature review, five described disease surveillance systems in two or more countries. Seven publications referenced systems centered in Africa, 5 based their

research in Asia, 4 in South or Central America and 3 in Europe. The primary objective of the gray literature review was to identify factors related to the successful implementation of electronic disease surveillance systems in developing countries. The researcher grouped the factors revealed in these publications according to the five World Health Organization (WHO) components of a disease surveillance system (Figure 4).

According to the WHO, the components of disease surveillance systems address: a) priority diseases for surveillance, b) system structure, c) surveillance core functions, d) surveillance support functions, and e) surveillance quality. These components provided the basis for the indicators included as part of the WHO guidelines for monitoring and evaluation (101) that have been used to improve disease surveillance system performance

The results of the gray literature are summarized below and the researcher developed a table in which the details of each publication selected were presented (Appendix J).

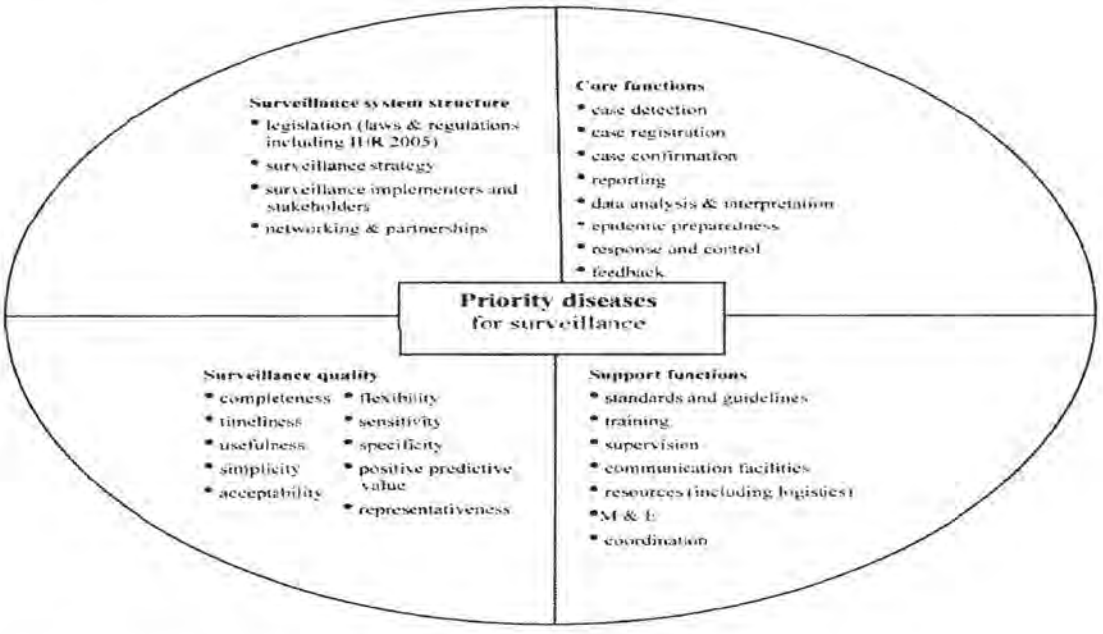

Figure 4: WHO components of disease surveillance systems (101).

System structure

Within the WHO system structure, the researcher identified the following nine elements of electronic disease surveillance systems that were mentioned in the gray literature: political commitment, advocacy, legal framework, financial commitment, surveillance strategy, surveillance tool, system organization, accountability, and development of partnerships and networks. Each of these elements will be discussed further in the following section.

Political commitment

Authors of publications found while searching the grey literature mentioned political commitment as a critical component in the successful implementation of a disease surveillance system. They indicated that obtaining the support of all levels of government was of primary importance in system implementation (38), especially during the early implementation phase of the implementation process (81). In addressing the implementation of the Ugandan disease surveillance experience, Lukwago, Nanyunja, Ndayimirije, Wamala, Malimbo, et al., for example, identified a need to institutionalize the surveillance system in the organization's agency and the public health budget (61). According to the WHO and others, a high level of commitment from the leaders of the organizations involved in the implementation process can be translated into the development of a health plan and policy that includes surveillance and epidemic preparedness as major components (30; 86; 99), and that assures resource allocation to surveillance (30; 98; 99). Moreover, as illustrated in the Ugandan surveillance project, Likwago et al. observed that strong support from the Minister of Health allowed all health workers to be sensitized to the relevance of surveillance work (98).

Advocacy

Five publications in the literature review referred to a need to achieve political commitment for surveillance through the formal sensitization of political and surveillance stakeholders (93; 98). Advocacy for a surveillance system proved useful in several areas: stimulating awareness of the importance of surveillance among stakeholders (61; 76), securing required resources (93), and generally improving the system (61). According to a WHO publication, the use of functional surveillance models, demonstrating cost-effectiveness and providing regular updates on the performance of the surveillance system (99). However, the implementers of a disease surveillance system in Sri Lanka warned others to consider the time needed to obtain this support during the planning phase of the system (81).

Legal framework

The legal framework for surveillance was identified as a priority in implementing and strengthening disease surveillance systems (93; 98; 99). The legal framework was also cited by the WHO as key to the effective coordination, integration, and sustainability of the systems (99), and to support the funding required to initiate and sustain the system (30; 102). The authors of a United States Agency for International Development (USAID) supported project in Georgia described utilizing surveillance legislation to address the legal and administrative barriers that may prevent the effective functioning of the system (76).

Financial commitment

While not the only element needed, a review of the progress and challenges of a disease surveillance system initiated in Uganda revealed that financial commitment was

related to an increase in the performance of the surveillance system (61). Williams et al who assessed a disease surveillance system in the Republic of Armenia, identified the strength of a systems as originating from the separation of preventive from curative medicine, which meant having an independent status and budget for surveillance (105). Lack of dedicated funding was described as a challenge by the authors of publications describing disease surveillance in the developing countries of Georgia, Ghana, Lithuania, and Tanzania (30; 38; 76; 77). Franco, Setzer, and Banke noted that the absence of funds affected surveillance personnel supervision and training as well as the support of the system in general (38).

The authors of xix publications mentioned the presence of strong donor support that enabled developing countries to implement their surveillance systems (30; 32; 38; 81; 98). At the same time, the authors of the Georgia immunization surveillance program explained the importance of donors' demand that governments financially commit to the system in order to ensure its sustainability after donor assistance ceased (76). It was notable that the commitment of the government of Georgia to finance a surveillance system in that country was achieved by developing an advocacy strategy and materials for the government to understand why the system was a priority for the country (76).

Surveillance strategy

The development of an overall strategic vision was presented as an important task before implementation. One publication mentioned that without such a vision, donors could drive the system towards their own interests instead of following the organization's interests (76). Therefore, this publication noted that the system should reflect the high priorities of the organization where it will be implemented (76). The

importance that the plan of action is based on the assessment of the needs of the organization was cited (98). For one author, this plan should also consider the administrative arrangements and the local contexts in each country when designing the surveillance strategies. The example provided was the selection of a district-focused approach for their disease surveillance system in a decentralized country (99). Advanced planning was recommended in one publication, especially when expanding sites for the system (61).

Information in the gray literature reflected a need to move toward the integration of surveillance activities since, as the WHO observed, vertical systems had proven to be expensive and difficult to sustain (99). As illustrated by Kant and Krishnan, authors of a case study that addressed disease surveillance-related information and communication technology in India, the integration of disease surveillance in a country could be accomplished through the establishment of surveillance units at national, regional and district levels (55).

An additional element for inclusion in any surveillance strategy was the use of collected information by decision makers (38; 105). Reporting on the Sri Lankan infectious disease surveillance system, Robertson, Sawford, Daniel, Nelson, and Stephen underscored the importance of identifying system outputs and their utility early in the system design process (81). At the same time, disease surveillance reforms in Georgia revealed that implementers should develop materials to help health care workers understand and see how the data collected would be used (76).

Surveillance tool

In concert with the recommendations of Jefferson, Dupuy, Clauder, Texier, and Green, the reliability and availability of surveillance tools was essential for the performance of the disease surveillance system, as an unreliable tool provided poor data and the unavailability of the tool(s) to reporting staff hindered their surveillance activities (52). The WHO reported that surveillance implementers recommended maximizing the use of information technology for surveillance activities (99). Robertson et al. described the use of familiar technologies such as basic cell phones in Sri Lanka disease surveillance, which not only enabled timely data collection and transmission, but also decreased training times (81). In Uganda, however, surveillance implementers encountered the challenge of a lack of standardized surveillance tools and software, where several organizations and partners used different tools for data collection and dissemination (98). In addition to maximizing the use of familiar and basic information technology, standardizing reliable surveillance instruments and software within the system, and ensuring the availability of instruments to staff, Robertson et al. recommended that surveillance systems must guarantee the appropriate security of data that they collect (81).

Organizational aspects

In two publications, implementers of surveillance systems recommended creating an adequate organizational structure with clear roles and responsibilities at every level of the system (38; 76). Reflecting on disease surveillance in Tanzania and Ghana, Franco et. al mentioned the possibility of failure if the surveillance strategy did not take into account key organizational and workplace issues and constraints (38). The implementing team should be prepared to perform continuous assessment of the system and identify the

problems in order to support the reporting staff in fulfilling their surveillance tasks (38). Due to limited resources, programs need to implement collaborative team-work at every site and at different levels of the system (86). Team spirit and trust have grown among stakeholders with more programs working within integrated surveillance systems (98). In terms of surveillance staff retention, the WHO recommended that donors be allowed and encouraged to provide the necessary financial incentives to retain effective workers, even if such salary supplements would cause disparities and would not bear sustainable in the long run. A need existed to change the attitudes and behavior of the health workers . Behavioral change was critical in the application of training skills (99).

Accountability

Franco et al. identified the need for accountability as part of an overall surveillance strategy (38). Both Franco et al. and John, Samuel, Balraj, and John observed that the absence of effective enforcement strategies within surveillance systems, particularly the reporting process, led to a low performing system (38; 53). However, implementers also commented that some enforcement efforts could be counterproductive and lead to a negative reaction by reporting staff. For instance, Franco et al. reported that administrators in a Tanzanian surveillance system attempted to hold the salaries of reporting staff if surveillance reports were not submitted on time. This enforcement strategy was unsuccessful in that it did not improve performance and created an even greater negative perception of the system (38).

Partnerships

The WHO identified the establishment of partnerships with public and private agencies, as well as with stakeholders from the central and peripheral levels as critical to

the successful implementation of disease surveillance systems (99). The WHO and Franco et al. noted support from international partners in implementing disease surveillance systems, including resource mobilization, formulation of training policy, and development of standards and guidelines (38; 99). For instance, Lithuania took advantage of the Swedish experience with electronic reporting systems to support the implementation of their system (30). Technical support from the Centers for Disease Control and Prevention (CDC) (Atlanta, Georgia) and WHO was used to improve the performance of a Ugandan surveillance system (61). However, according to Robertson et al., technical assistance should focus on developing local expertise from the start of the process in order to ensure sustainability of the system (81). Forging partnerships fostered the strengthening of surveillance, training, and laboratory networks at the local, national, and regional levels (56; 99). For these networks to work efficiently, however, the existence of a strong national coordination body (56; 99) and effective coordination mechanisms proved useful (32; 99). These coordination efforts were especially needed at the regional and district levels, as well as the MOH level in surveillance systems (102).

Surveillance core functions

Within the surveillance core functions, the information revealed by the gray literature included *data analysis and interpretation, and the feedback processes*. Each of these core functions will be addressed in the following section.

Data analysis

Due to analysis capacity challenges at the lower levels of surveillance systems, the gray literature reviewed suggested using epidemic thresholds based on technical guidelines to improve outbreak detection (98; 99) and the development of automated

analysis to facilitate tasks at the local level (87). The WHO also noted a need for improved data management at the central level (99).

Feedback

Feedback was deemed an important component of the system, particularly in efforts made to inform health-related surveillance workers about the data they collected and how the data were used. Feedback could be offered through weekly newsletters, website updates, press releases, field investigation reports, and quarterly bulletins (99; 102). The WHO recommended that such feedback be produced regularly and in a timely way at the central level (99). In an evaluation of a surveillance system in South Africa, Weber recommended the dissemination of surveillance results to a wide audience of health care providers with a clear explanation about how the information collected had influenced the response to outbreaks or was used to assess the public health interventions that had been implemented (94). Understanding the importance of disease surveillance information served to motivate reporting staff. Feedback was also recognized as a critical element in an effective accountability system (38). John et al. and Wuhib, Chorba, Davidiants, MacKenzie, and McNabb noted that a failure to report feedback to reporting staff created a barrier to realizing improvements in the performance of these staff (53;105). Weber, for instance, noted that staff who received no feedback shared that they did not perceive any public health use of the data they had collected and reported (94).

Surveillance support functions

Within surveillance support functions, the gray literature offered information on establishing standards and guidelines, training, supervision, communication, resources,

and monitoring & evaluation. Each of these support functions will be addressed in the following section.

Standards and guidelines

The implementation of a disease surveillance system requires clear policy directives and guidelines for all surveillance functions (85). These guidelines should be standardized at the central level, which ensures surveillance is conducted using similar methods and resources at all surveillance sites throughout the country (38). These guidelines should include rules and procedures for data collection, transmission, analysis and dissemination (76). In addition, a standardized protocol for identifying and responding to outbreak alerts should be included to improve timeliness and usefulness of the system (52; 99). These documents should exist and be available in formats that are easy for workers to understand and use (38), and be distributed to every surveillance site at the peripheral level (93; 102). Kebede, Gatabazi, Rugimbanya, Mukankwiro, and Perry, et al. described how the use of multiple forms from a variety of partners for disease surveillance duplicated effort and wasted resources (56).

An additional element mentioned in the area of standards and guidelines was the list of diseases or events to be surveyed. The WHO and authors of surveillance system assessments in Ethiopia and Uganda recommended that national, provincial and district health departments prioritize and update their lists of diseases, considering the public health importance of these health problems (97-99). In addition, standard case definitions for priority diseases should be developed and distributed to all health facilities (98; 105).

Training

Training of health care personnel was considered one of the key factors in the success of disease surveillance programs (23; 87; 99; 105). Training was key in system performance (77) and, as reported by Sow, Alemu, Nanyunja, Duale, Perry, and Gaturuku, contributed to the improvement of timeliness and completeness in reporting surveillance events (88). Weber recognized training as a necessary component of quality assurance (94). Moreover, a train the trainers model that involved training health district officers in training and supervising new staff addressed one of the greatest challenges that these countries faced: a typically high staff turnover (80; 102).A key training recommendation revealed in the gray literature was to implement a sustainable strategy to systematically train human resources in surveillance (85; 94; 99). Robertson et al. and Siswoyo, Permana, Larasati, Farid, Suryadi, and Sedyaningsih emphasized the need for ongoing training (81; 86), including developing training modules as part of a routine program of continuous education (76; 77). The WHO noted a lack of training in epidemiology across all health care professions and recommended the incorporation of epidemiology training into undergraduate courses (99).

Kant and Krishnan recommended surveillance skills training that targeted health workers at different levels of the system (55), in order to provide them with the skills to perform the tasks required (61), especially those at the mid and peripheral level (99; 102). Due to the different skills required at each organizational level, courses tailored to the target population of learners were essential (99). Curioso, Karras, Campos, Buendia, Homes, and Kimball mentioned the need to customize training for different locations as personnel at some sites needed more extensive training (23).

Regarding the content of training, Sow et al. recommended that skills to be addressed include core surveillance functions such as detection, data analysis and reporting of diseases (88). In a publication recounting the implementation of an electronic Peruvian surveillance system, Soto Araujo-Castillo, Neyra, Fernandez, and Leturia, et al. suggested broadening surveillance training to include topics such as outbreak response (87). According to the WHO, effective surveillance training included the provision of appropriate guidelines, job aids, and tools (99).

Supervision

According to the gray literature reviewed, training was observed to be critical but insufficient in sustaining the implementation of a disease surveillance system over time. Adequate supervision was key to maintaining and improving the system's performance (38; 98). More specifically, Sow et al. pointed to supportive supervision at the district level that addressed the reporting staff's surveillance knowledge as likely to sustain the performance of surveillance (88). Franco et al. recognized supervision as a critical element for effective accountability (38). Supervision also provided an opportunity to train staff (38; 98) and address problems and issues at the site (38). According to Franco et al., the development of supervision guides was needed in order to facilitate this activity and ensure that capacity building would occur (38). A study by Huaman, Araujo-Castillo, Soto, Neyra, and Quispe JA, et al. challenged the impact of supervision on data reporting. These authors revealed that, although monthly supervisory visits associated with a surveillance system in Peru allowed closer contact with reporting personnel and the consequent improvement of data quality at some sites, supervision did not improve the timely submission of surveillance data (47).

Communication

Communication was considered by Robertson et al. to be instrumental for successfully implementing a disease surveillance system (81). The enhancement of regular bidirectional communication among different stakeholder groups could be increased by the quality and frequency of the communication by the groups (55; 94). Defined communication channels between various levels of the health system should exist and be usable, especially at the district and facility levels. In the same way (38), explicit linkages with relevant MOH divisions were quite useful (56). The WHO contended that communication was an important means of informing reporting staff about performance expectations, including providing a list with defined tasks, competencies and responsibilities (99). Furthermore, communication could be used to raise awareness of health workers about the basic principles of disease surveillance and to develop a commitment to the task of surveillance (98). This was achieved by regular and coordinated dissemination of information to the public and health workers (99). Some of the more useful sensitizing activities involved direct communication with health workers with information that was relevant to their setting (102).

Resources

The success of the implementation and continuation of a surveillance program was related to the availability of adequate resources for the activities these processes entailed (38; 85; 99). Sufficient resources for implementation were deemed important, such as collection forms, computers, and phone lines (38; 76; 86). However, one of the most frequently described challenges reported in the literature was a weak general infrastructure and shortage of equipment, supplies and reagents (56) and in some cases,

lack of resources at the national level (30). Therefore, the using available resources and adapting tools and strategies already in place was a strategy strongly recommended in order to ensure the sustainability of the system (30; 38; 81; 87; 99).

Regarding the technology used, Robertson et al. reported that open-source software options were preferred over proprietary options due to the lack of or reduced costs of open-source options (81). An expansion of a surveillance system required careful consideration of the availability of resources, not only surveillance staff for each new site but the infrastructure that would allow the staff to perform effectively (61). One successful story described by Soto et al. involved adapting a surveillance system to the existing resources of the organization and using alternative ways to transmit the information, such as the use of radio relay to expand the system to sites where no other technology was available (87). The use of radio was recognized as an important tool to reach remote areas with poor transportation networks and lack of telephone communication (102).

The WHO and others identified the laboratory capacity at surveillance settings as a critical challenge that included the limited availability of qualified personnel and shortages of equipment, reagents and staffing at the district level (93; 98; 99). The WHO recognized the presence of a laboratory network as a critical component of surveillance systems (99). Therefore, implementers noted the need to strengthen the capacity of the laboratories and establish referral networks within private and public sectors (99). The authors who described a successful disease surveillance system in Peru reported collaboration among different laboratory initiatives in the region instead of building an entire laboratory network in an effort to avoid duplication of efforts (87).

Human resources

The largest reported barrier to successful implementation of disease surveillance systems was the lack of adequate human resources (32). Several publications described the challenges surveillance systems faced due to an insufficient number of skilled human resources (38; 56), at high workload for a limited number of staff (77; 94) and the high level of attrition (98) in these settings. Therefore, the need to develop human resources was considered critical (32; 81; 86; 93; 98).

Adequate staffing should come with clearly defined roles and responsibilities. Moreover, a person exclusively dedicated to entering surveillance data was noted to be ideal and one of the key factors for the success of a system in Indonesia described by Siswoyo, Permana, Larasati, Farid, Suryadi, and Sedyaningsih (86). Conversely, low levels of performance in a Ugandan system were related to not having a dedicated surveillance officer at the provincial unit who could monitor compliance of the surveillance units (94).

While adequate numbers of skilled personnel were critical for carrying out surveillance tasks, high performance was observed in sites with sustained commitment of the health facility personnel such as a surveillance program in the African region reported by Sow et al. (88). Siswoyo et al. considered the commitment of the reporting staff a key component to the success of the implementation and the sustainability of a surveillance system (86). Robertson mentioned commitment as a particularly important characteristic when introducing a novel surveillance method (81). Domeika, Kligys, Ivanauskiene, and Mereckiene agreed with this idea, reporting that even when a Lithuanian staff had the

heaviest workload, they were motivated to change to an electronic reporting system due to their commitment (30).

For commitment to be achieved, implementers needed to convince stakeholders that their surveillance efforts were useful and their valuable time was not being wasted (87). Several strategies to motivate reporting by staff were described in the literature reviewed (99). These included creating career incentives (97); awarding financial (76) or non-financial prizes to districts with good performance on the basis of timeliness and completeness of reporting (98); providing medical equipment to the sites; and inviting reporting staff to participate in annual epidemiology workshops and meetings (80). Conversely, there was also a mention of the inability of a system to develop adequate financial and administrative incentives (76). Wahib et. al discussed the use of reported data to blame and sanction reporting staff rather than to implement effective interventions. This behavior hindered outbreak reporting due to fear of these sanctions (105).

Monitoring and Evaluation

The WHO contended that monitoring was critical for identifying system progress (99), and maintaining and improving its performance (38). Follow-up was also noted to be an important component of the accountability system (38). Soto et al. identified having a fully dedicated person to monitor all the surveillance sites as one of the most successful strategies in implementing a surveillance system in Peru. This strategy proved to be particularly important during the expansion phase of the system (87). A study of this same system (Huaman et al.) demonstrated that regular phone call reminders before a reporting deadline improved the timeliness of reports (47). Franco et al. reported that

districts in Tanzania and Ghana that received less follow-up did not improve their performance as much as those districts that received follow-up (38). A report on disease surveillance in Tanzania revealed that national and regional teams were instrumental in ensuring the continuation of monitoring activities (77). The report also noted that it was useful to provide districts with tools to support them in the continuation of their surveillance monitoring activities (77). The authors of three publications mentioned regular evaluation as a required element in assuring the optimal functioning of a system (87; 94; 102).

Surveillance quality

Within the surveillance quality component of disease surveillance, the literature referred to two elements: *simplicity*, and *flexibility*. Each element will be addressed in the following segment.

Simplicity

Five publications described the importance of having a simple system. Wuhib et al. identified complex systems as unsustainable (105). The simplicity of the surveillance task was related to the acceptability of the system by staff (52). Jefferson, Dupuy, Clauder, Texier, and Green noted the importance of limiting the list of diseases or syndromes under surveillance or the amount of information required to be collected in order to reduce the amount of time taken to input required data (52). The authors of two publications commented on the need to have simplified surveillance forms or tools (98) and how a lack of surveillance tools negatively impacted surveillance system performance (88). A publication authored by the WHO, CDC, and USAID identified the

need to lessen the burden of reporting staff by minimizing the duplication of the data collected at the sites (102).

Flexibility

The WHO mentioned the importance of the surveillance attribute of flexibility in the design of the surveillance strategy in order to address the surveillance needs. Flexibility was noted as an important factor when designing the electronic tool used for the surveillance processes (99).

In summary, as shown in Figure 5, elements related to each of the four WHO components of disease surveillance systems were identified as important to the successful implementation of electronic disease surveillance systems in developing countries. The components of surveillance structure and support functions offered greater opportunities for implementers to increase the probability of succeeding in the implementation process, when compared to the other two components. For the surveillance structure components, important concepts were recognized, including political commitment, advocacy for surveillance, legislative framework, financial commitment, surveillance strategy, surveillance tool, system organization, accountability, and partnership and frameworks. In the support functions component, the importance of elements such as standards and guidelines, training, supervision, communication, resources, and monitoring and evaluation were highlighted. In the core functions component, feedback and the analysis of the data concepts were considered critical to enhance the performance of such systems. Finally, in the surveillance quality component, two attributes of simplicity and flexibility were described as related to successful systems. Other attributes, measured in a few publications, related to surveillance quality included completeness, timeliness, sensitivity

and specificity. However, these latter attributes were not described in the literature as critical to the successful implementation of an electronic disease surveillance system.

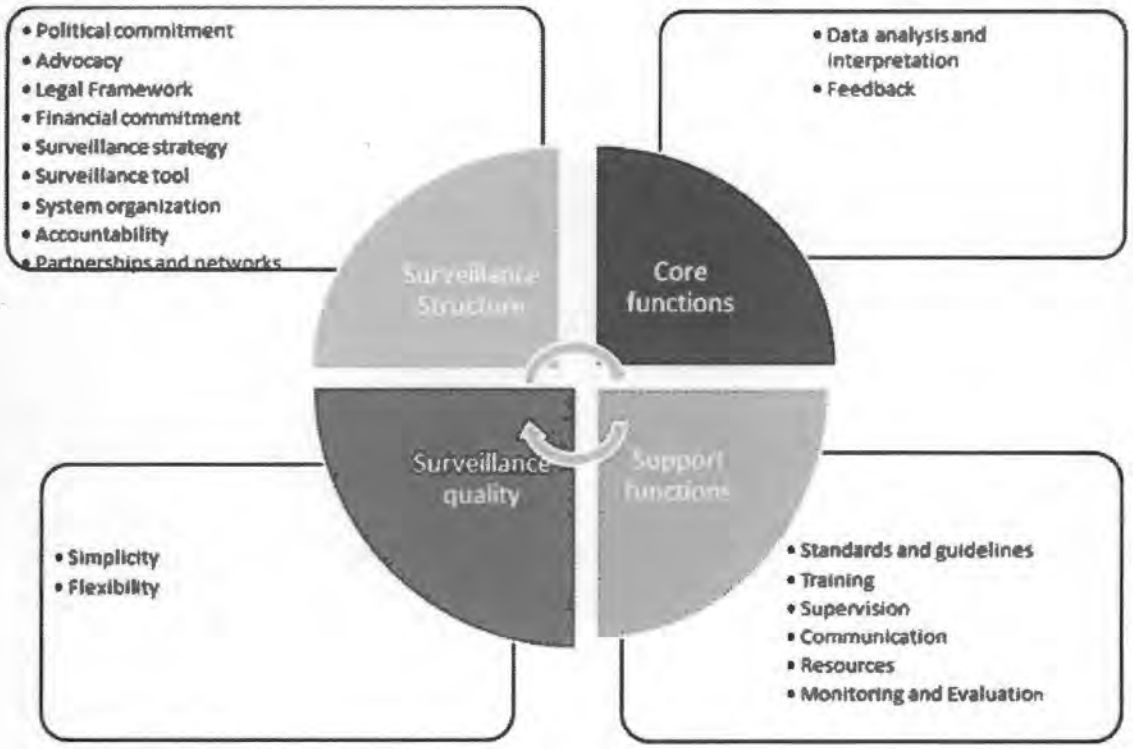

Figure 5: Summary of literature review of successful implementation of electronic disease surveillance systems in developing countries.

CHAPTER 4: RESULTS – EXPERT CONSENSUS WORKSHOP ON ELECTRONIC DISEASE SURVEILLANCE

After exploring and analyzing the literature available on electronic disease surveillance program implementation, the researcher gained consensus-based insight from experts in the field of electronic disease surveillance. She convened these experts for a one-day workshop that was intended to address the three following questions outlined in the Methods section: a) what is the definition of electronic disease surveillance? In order for a system to be considered electronic, how does technology need to be included in the process of data collection, analysis and feedback?; b) Are there stages or phases in the process of implementation of an electronic disease surveillance system in a developing country? If so, describe each implementation stage or phase, successful implementation milestones for each stage or phase, and identify the performance attributes to be prioritized and the indicators to monitor such attributes; c) What are the key factors (e.g., technical considerations, surveillance system structure, core and support surveillance functions, surveillance quality, financial considerations, political considerations, ethical and cultural considerations, organizational and workforce determinants) related to a successful implementation of an electronic surveillance system in a developing country?

. The results of the workshop contributed to this study by adding experts' in-depth knowledge on electronic disease surveillance in general as well as surveillance under low resource conditions, informing the development of the grounded theory study, and providing an additional key source of data that ultimately contributed to the development

of a model for implementing electronic disease surveillance systems in low resource countries.

On February 22, 2012, fifteen subject matter experts (Appendix G) in electronic disease surveillance convened at the Armed Forces Health Surveillance Center (AFHSC) in Silver Spring, Maryland for a one-day workshop on electronic disease surveillance implementation in developing countries. Workshop outcomes addressed the lack of literature (published and gray) related to electronic disease surveillance and the need for guidance on improving surveillance capabilities in developing countries. The desired outcome for this expert workshop was the development of consensus definitions or descriptions of concepts relevant to electronic disease surveillance purpose, operation, performance, and implementation in developing countries. The agenda of the workshop is included in Appendix K.

Dr. Patrick Kelley, National Academies of Science Institute of Medicine Senior Director of the Boards of Global Health and African Science Academy Development, provided an initial overview of public health surveillance systems in an effort to set the stage for the workshop discussion. He defined disease surveillance in the following way:

> *A system for public health surveillance is a group of integrated and quality-assured, cost-effective, and legally and professionally acceptable processes, designed for the purpose of identifying in an ongoing, flexible, standardized, timely, simple, sensitive, and predictive manner the emergence of meaningful epidemiological phenomena and their specific associations. These processes include human, laboratory, and informatics activities to skillfully manage information derived from an entire defined community and to disseminate that*

information in a timely and useful manner to those able to implement appropriate public health interventions' (49).

After significant small and large group discussion, workshop attendees reached consensus regarding a definition of electronic disease surveillance and its implementation in developing countries. They also achieved consensus regarding critical elements of a disease surveillance system. These key elements included: a) clearly understanding the health issues or events that required surveying before developing the system; b) identifying what was to be surveyed, including whether the system would track infections, syndromes or other events; c) determining the data collection process (face-to-face, electronic, or a combination of both); d) identifying a feasible surveillance question, considering the available resources from the country and donors; e) specifying the kinds of data to be collected; and f) identifying or developing a data collection instrument to address the purpose of the surveillance in a given context. Most electronic surveillance systems selected and used an electronically-based tool to facilitate a national surveillance process at multiple levels.

Workshop participants identified two priority areas for surveillance system development: a) the creation of global system architecture for a surveillance system; and b) the development of human resource networks, which is particularly challenging in the developing world because training needs existed at multiple levels. They suggested that surveillance training address the following content areas: a) how to plan for and use data that were collected, b) how to think epidemiologically, and c) how to analyze data and report findings.

The expert participants agreed that implementation of a disease surveillance system required consideration of inputs, activities, and outputs in order to achieve desired short and long-term outcomes. They advocated that surveillance professionals adopt a common, longer-term aim of effective disease control rather than a more short-term focus on the production of surveillance tools or analytical graphs. Participants concurred that the attributes of a public surveillance system described by the Centers for Disease Control and Prevention (CDC) could be applied in the framework of inputs, processes and outputs (16).

A gap in surveillance system development identified by workshop participants during their discussions was the absence of a standardized surveillance implementation model and models for the surveillance processes. During the discussions the experts did not reach consensus regarding the specificity of surveillance system development. One expert contended that surveillance problems arose when different countries and organizations expended large amounts of resources and time in developing customized solutions to their surveillance issues. This expert suggested a need to develop a standardized basic system that was flexible enough to be adapted to different realities. Alternatively, other experts suggested focusing on developing situation-specific technology to fit a particular situation rather than developing technology to meet the general needs of an institution, organization, or country. While consensus was not reached on this issue, the need for system flexibility emerged from the discussions

Defining electronic disease surveillance

In order to address a key workshop goal, workshop members were charged with reaching consensus regarding a definition of electronic disease surveillance, recognizing

the increasing use of electronic tools that have provided new and innovative ways to conduct surveillance. The experts acknowledged that the motives for and outcomes of disease surveillance, particularly those related to the protection of public health, have changed little over time. The methods by which data have been transmitted and the tools available for transmission, however, have evolved.

The experts identified two main areas within the process of disease surveillance where electronic tools were primarily used: data collection and data analysis. They contended that a system could be deemed electronic if either one of those processes was electronic. The term "electronic" basically meant that computer software was used in the surveillance process. At the time of this study, the ability of a system to employ an electronic means of surveillance was an important consideration for surveillance developers since Internet access and electronic data sources were rarely consistently available in the developing world.

Workshop experts acknowledged that almost every disease surveillance system in developing countries required staff to manually enter data at some point. Although some data could be directly read by computer software such as laboratory test results, other data such as patient demographics and diagnoses were typically manually entered into the system.

Some workshop participants suggested a change in terminology that involved replacing the term, "electronic," with a reference to the purpose of a particular surveillance system. Surveillance professionals could use the term, "early warning system," for example, which may or may not be electronic. Members of the workshop, however, failed to achieve consensus on this point.

Implementation phases for electronic disease surveillance systems

Workshop participants agreed upon five key phases that comprised the process of electronic disease surveillance system implementation. The participants considered the context of implementation as one in which an external agency or donor organization supported a resource-limited country to implement a surveillance system. The phases of implementation identified by participants included partner country contact, assessment of preparedness, development of a plan, system implementation, and system monitoring, each of which will be discussed below.

Partner country contact

The first phase included identifying a key contact person in a partner country's surveillance organization who had the capability and authority to support the implementation of a surveillance system. This individual might be the Minister of Health or the Director of the MOH epidemiology office but must be someone who could authorize the work needed to plan and implement a surveillance system that would ultimately be institutionalized at a national level

Assessment of Preparedness

Workshop experts identified preparedness assessment as the second phase of surveillance implementation. Assessing the preparedness of the institution, organization, or country to implement an electronic surveillance system included gaining insight into the environment in which implementers would be working. To gauge the level of preparedness, implementers must determine the motivation and direction of the institution, organization, or county and the existence of or potential for surveillance legislation.

Determine motivation and direction.

Workshop experts emphasized the importance of determining the type of surveillance system in which a particular country was interested, including the intended scope of surveillance, particularly whether the aim was to survey single or multiple diseases or conditions. In addition, an assessment of the strength of political will was necessary due to a recognized need for strong political support in the implementation of such systems. They also recommended that the existence of political motivations underlying decisions regarding system design and implementation capabilities be evaluated and the expectations of country leaders be assessed for evidence of realism and rationality. They advised system implementers to address the country's expectations during this phase of the process in an effort to prevent future difficulties and misunderstandings.

Determine the existence of surveillance legislation.

Workshop experts agreed that identifying government policies and the existence of surveillance-specific legislation were key elements to be addressed in this phase of the process. A list of nationally notifiable diseases was one of the first documents that workshop experts recommended that implementers review.

Assess country readiness.

Workshop experts recommended that implementers assess the readiness of the country for electronic disease surveillance by performing a basic assessment of the infrastructure for surveillance at every level of the system. This infrastructure included equipment, phone lines, internet, computers, and laboratory capability. In addition, they

contended that it was critical to assess the expertise, knowledge, and ability of the surveillance authority and surveillance staff at every level of the system.

In order to develop a maximally effective and efficient surveillance system, workshop experts directed implementers to gain insight into existing surveillance processes in the country and the type of data already being collected. Such insight would enable implementers to identify collaboration opportunities and effectively integrate new surveillance needs into existing surveillance systems. In addition, they deemed it essential for implementers to identify all surveillance tools in current use and their user interfaces in order to develop similar, compatible interfaces, if feasible.

Assess financial support.

Another key element to assess in the process of developing and implementing an electronic disease surveillance system, according to workshop experts, was the certainty of the funding source for the system and the duration of the sponsorship. Additional donors/sponsors should be considered in order to achieve resource diversification. The experts advised implementers to convene a meeting of interested donors to discuss surveillance needs, planned activities, and resource requirements. Such a donor meeting would be beneficial in determining the levels of commitment (i.e. financial, technical) intended by each potential donor.

Identify surveillance needs.

Experts who participated in the workshop underscored the need for implementers to clearly understand disease surveillance priorities and needs within a given country. For example, implementers must identify not only the scope of surveillance, including the

range of diseases to be surveyed, but also the personnel required and levels of engagement by and commitment of health care system personnel who are involved in reporting data.

Develop a Plan

The third phase identified by workshop participants as the development of an implementation plan that is based on the assessment described above. The surveillance implementation plan should be based on a strategic plan and existing surveillance processes:

a) Implementers must consult the strategic plan for public health in the country of interest. Surveillance represents a relatively small segment of a national public health plan and should be designed and implemented in compliance with a country's existing public health plan.

b) Use surveillance processes already in place. An electronic disease surveillance system should be designed to fit the processes already in place if possible. Implementers must consider the ability of the surveillance system to communicate with other systems in the future.

The workshop experts identified planning for the general design of the system, a demonstration project, and the development of metrics as part of the implementation phase of an electronic surveillance system

a) In terms of general design, implementers should plan a hierarchical, top-down system that begins at the national office and progresses to the most distal point of the system. They recommended initiating a public health data repository at the national level

for data collection, analysis, and comparison to or integration with other existing surveillance systems.

b) Demonstration project plans are advantageous. Workshop experts recommended that implementers consider conducting a demonstration project before full-scale implementation of a system, always with a view toward larger system integration.

c) Metrics should be developed to generate the information needed to assess system impact and processes that include all intermediate phases of surveillance. The experts strongly advised considering one particularly important metric: the degree to which the plan adhered to 'global' standards of disease surveillance as defined by the WHO and CDC (15; 100).

System implementation

The fourth phase, implementation of the system, involved conducting a demonstration project, scaling up, and monitoring and evaluation, each of which is discussed in the following segment.

a) Demonstration project. The system implementation aspect of the aforementioned demonstration project consisted of using a means of collecting feedback from various individuals and groups to determine if the system was working effectively from both an informatics and end-users' perspective. The experts advised implementers to use strategies such as focus group interviews to obtain feedback crucial in refining surveillance processes. Not only did insights from individuals aid in designing more efficient and effective processes, but also such feedback contributed to planning relevant in-service training opportunities for surveillance staff.

b) Scale up. Workshop experts advocated that surveillance sites be added based on available resources and sufficient monitoring capacity at the regional or national level. During this period of implementation, workshop experts stressed the importance of implementing a continuous rapid cycle assessment that fed information back into the system for the purpose of improvement.

c) Monitoring and Evaluation. The experts advised that strategies in the areas of monitoring and evaluation be established prior to initiating the system. The aforementioned rapid cycle assessment used feedback from system users to identify ways to improve the system and quickly share improvement strategies across all surveillance sites. The training outcome of rapid cycle assessment involved in-service education that, in some cases, included bi-directional training in that users taught trainers and vice versa. The experts believed that this approach also supported stakeholder buy-in. Workshop experts recommended that, when possible, implementers employ automated features developed within the tool to ensure the quality of the data collected.

System Monitoring

The last phase of implementing an electronic disease surveillance system as identified by the workshop experts was system monitoring. The experts based their recommendations for system monitoring on the basic program logic model described in the CDC guide titled, "Introduction to program evaluation for public health programs". The elements of this model are: Inputs, Activities, Outputs, and Outcomes (16). This model was used to cut across the various monitoring areas.

Timeliness of data reported

At the national or regional level, timely data analysis and reporting was viewed by the experts as a primary activity in disease surveillance. In order to assess the timeliness of data collection, reporting and analysis, they recommended that the surveillance tool enable the recording of lag time between disease event occurrence dates and subsequent event reported dates. Experts contended that the optimal lag time between the clinical presentation of a health event and the date it was reported (outputs) was no more than 72 hours. Workshop experts also recommended that implementers assess the difference in time between the data collection as evidenced by form completion and the date when data were entered into the system.

A final consideration related to the timeliness of data reporting was system capacity and support for timely decision-making. According to workshop experts, one of the challenges surveillance system implementers have traditionally faced has been a failure to initiate public health interventions at a time when data suggested that such actions might reduce morbidity and mortality. Based on their shared experiences, the experts concluded that a lack of response to data findings that signaled a need for action was generally due to a lack of analytical capacity on the part of surveillance personnel.

System Flexibility/adaptability

Workshop experts described system flexibility needs at two primary levels: the level of the surveillance instrument (tool) and the larger system level. Implementers must develop surveillance tool features that enabled respondents to address new questionnaire items if needed. Implementers, for example, might be requested to create a new report in response to International Health Regulations, 2005 (IHR (2005)), thus necessitating an change in the tool used to collect data.

The surveillance system itself should have the flexibility to incorporate new directions such as different diseases or syndromes, the importation of different data sets, a readjustment in the categorization of data or a change in data analysis (e.g., adding new algorithms), and the development of different entry profiles and data presented for different jurisdictions. One advantage of a flexible surveillance system is that it allows policy makers to frame reports and analyses required to make a case for policy changes that ultimately resulted in more effective disease control.

Stakeholder acceptability

Workshop experts insisted that any surveillance system that is implemented must be legally and ethically acceptable to stakeholders. All data should be handled in a legal, ethical, and professional manner, yet be legally available to appropriate surveillance personnel. A security process must guarantee the protection of individuals' privacy by prohibiting access to personally identified data. Moreover, protection from security system violations must be assured.

An additional aspect of surveillance that workshop experts encouraged implementers to consider in their efforts to develop an acceptable surveillance system was the sheer volume of data to be collected. The required volume of data should be manageable for and acceptable to surveillance staff, considering the resources that were available to them and the workload they shouldered.

Standardization

Workshop experts advocated the standardization of surveillance processes including having and consistently using clear guidelines for processes and employing

standard field case definitions and methodologies for diagnosis that allowed a comparison of outputs. They suggested that compliance with standards supported the generation of a standardized report. They also reiterated the importance of assessing the degree to which a system complied with global standards that would allow findings from the implementers' surveillance system to be compared to findings from other nations, thus increasing the possibility of averting transnational public health emergencies.

Usefulness

The usefulness of a system refers to the ability of data collected by a particular surveillance system to answer the questions of interest posed by various groups of stakeholder. In addition, the users of the system should be able to group the data as needed to learn about events taking place.

User friendly

An important system-related consideration proffered by the workshop experts was the ease of system use by surveillance staff. Modifications to the surveillance tool, for example, should be made following users' feedback and based on staff experience using the system to address stakeholder's surveillance questions.

Quality/Validity

Several indicators can be used to assess the quality of the surveillance data. The workshop experts suggested that one of the first and easiest ways was to monitor each surveillance site for the proportion of records found to be complete. For any surveillance system to be considered valid, system evaluators needed to consider the sensitivity and

specificity of data needed and the accuracy and completeness of reports related to those needs.

Scalability

The scalability of a surveillance system was defined by workshop experts as the resources required by implementers to use a developed surveillance tool in other sites within the same surveillance system. This process required the consideration of limitations and needs of every site or region within a particular nation and guides the process of developing or selecting and implementing a surveillance tool.

Sustainability

For a system to be sustainable, the panel of experts who participated in the workshop indicated that more than just financial resources should be taken into account. In their view, it was essential that governments and organizations have a strategy in place to develop the capacity needed to sustain the system when donors reduced or ceased their support

Portability

Finally, the workshop experts contended that it would be beneficial for implementers to assess the portability of the system. Portability was particularly important if a need arose to translate the implementers' experience with the system to other localities within or external to the region or country where the system originated.

Factors related to the successful implementation of electronic disease surveillance systems in developing countries

For the third and last overarching question that was addressed by the experts who participated in the workshop, the experts agreed that system fit and sustainability were factors they considered most clearly related to the successful implementation of electronic disease surveillance systems in developing countries.

Participants agreed that predicting success regarding a particular surveillance system depended on: a) how effectively the surveillance system fit the needs of a country or organization, and b) the sustainability of the system. Workshop participants agreed on ten key strategies to achieve fit and sustainability (Table 1).

Table 1: Factors associated with successful implementation of electronic disease surveillance systems (Expert consensus workshop).

Political will	• At every level of the system •Clear articulation of needs •Legislation •Local champion (Regional level)
Strategic vision and plan	•To map out sustainability •Inlcude: monioring and evaluation, and workforce development plan
Adequate finacial support	•Buid capacity and empower surveillance comunity •Avoid creating dependency on donors
Trained and available workforce	•Great challenge for developing countries •Provide skills to produce high quality data •Main gaps is on analysis of the data collected
Performance improvement plan	•Nurture culture to keep surveillance staff motivated •Use non-financial incentives •Provide regular feedback to end users of the system
Flexbility and adaptability	•Personnel and software need to adapt to changing environment •System able to incorporent different and new data sources
System is intuitive to end-users	•Average surveillance staff should be able to use the system •Simple but if needed, more complex analysis can be performed
Useful at all levels	•From local users to the national level •Feedback is important
Transparency of the data	•Develop data use agreements •Ensure data sharing is legal and ethical
Start small	•System should be tested and proved to work before it is expanded in large scale

Political will

According to workshop experts, political resolve about the need for and value of a surveillance system had to be present at every level of the system. At the national level, the experts believed that strong executive support was required as well as a clear articulation of country needs by the authority that conducted surveillance in the country.

The highest-level authority was advised by the experts to develop a coherent vision related to the needs of the country, and put in place a focal point or central coordinating office to oversee the system. Political will needed to be translated into regulation or legislation that formalized support for the surveillance system as well as the commitment of personnel and resources. At the regional level, the experts contended that it was important to have a local champion for consistent coherent oversight. The implementers should identify a person who believed in the system and was motivated to make it work. This person had to have the ability to engage key officials and influence the decision making process. According to the experience of the workshop experts, having the most senior management person at the organization involved in the implementation was correlated with success. At the local level, it is important to work closely with the end users to ensure usability and acceptability of the system. Ownership of the system needed to be present at all levels.

Strategic vision and plan

The workshop experts deemed the presence of a strategic vision and plan as critical to the implementation of an electronic disease surveillance system. They advocated that implementers develop a strategic plan to contribute to the country's ownership of the system and to map out strategies for sustainability. For this, implementers needed to consider the sponsor's financial and technical support in the

short and long term. The strategic plan should include a monitoring and evaluation framework for the system as well as an articulated workforce development plan.

Financial support

Implementers must ensure adequate financial support for the system in order to build the capacity needed for surveillance. The workshop experts recommended that donors provide resources to build the capacity needed and empower the surveillance community in the country, thus avoiding the problem of creating dependency on donors in the long term.

Human resources

A successful surveillance system requires an appropriately trained and available workforce. System implementers needed to identify the skill sets necessary to ensure the development of a surveillance team that was capable of producing quality data. The workshop experts advocated that implementers consider the technical, personality, organizational and cultural aspects of human resources development. They related that maintaining a permanent training program at the regional level has proven important in ensuring a well-trained workforce at every level despite the reality of the high turnover of personnel that frequently occurs in developing countries.

Training must be designed to address a lack of capacity at different levels and for different skills. Workshop experts said that one of the main surveillance training gaps in the developing world is training related to data analysis in order to enable surveillance staff to understand the data collected. Adequately trained data analysis managers become critical as data become more available.

Performance improvement plan

The presence of a performance improvement plan was considered essential by workshop experts in order to nurture a culture that motivated surveillance staff. The experts recommended using non-financial incentives in an effort to prevent the sustainability issues that tended to occur when monetary incentives were used. One of the successful experiences that an expert shared was the creation of a certain level of healthy competition among surveillance staff by annually acknowledging and awarding the health care facility that performed at the highest level. Providing regular feedback to end users of the system has also been shown to motivate surveillance staff.

Flexibility and adaptability

All aspects of the system needed to be flexible and adaptable. Personnel and software needed to be flexible and adapt to changing environments. The system should have the ability to incorporate new or different data sources.

Intuitive to end-users

Workshop experts recommended that disease surveillance systems be intuitive to end-users. In their view, the surveillance staff at the local level needed to be able to use the system without having an information technology degree. At the same time, the staff should have sufficient tools to conduct a complex analysis of data if needed. The system should to be simple to use and must prioritize data collection and access processes.

Useful at all levels

Surveillance systems must be useful at all levels, from local users up to the national level. Implementers should avoid creating a parallel system if a working disease surveillance system is already in place. The workshop experts recommended working within existing disease surveillance systems if such systems are available and useful. When developing a system, implementers should stay close to system users and listen to

what they need. An important means of emphasizing the usefulness of the system is to provide feedback on the information generated by the system to all stakeholders.

Data transparency

Implementers must ensure data transparency by developing data use agreements and facilitating data sharing between and among jurisdictions. Implementers must guarantee that all such sharing will be conducted legally and ethically.

Start small

The final recommendation by the panel of experts participating in the workshop was to encourage implementers to begin on a small scale. In that way, implementers can affirm that a given surveillance system works and that they have made all necessary changes before implementing it on a larger scale. The factors related to successful implementation of electronic disease surveillance systems in developing countries, agreed on by workshop participants are summarized in Table 1.

Data Triangulation

When the researcher compared the factors agreed on during the expert workshop with those cited in the literature reviewed in the previous chapter, she found similarities among all the components of the surveillance systems. Disease surveillance systems are relying more on electronic tools in order to develop more accurate and efficient ways to collect, translate, and communicate information. In their surveillance efforts that are generally supported by external organizations, developing countries are gaining increasing access to this technology. Technology, however, is not the most important component of a surveillance system. Country needs for surveillance must be clearly articulated and government commitment should be present from the beginning if there is

to be any hope for success in the surveillance effort. Donor support needs to be explicitly stated in terms of not only the financial resources commitment, but also the type and extent of technical support that the donor will offer.

Even when the aforementioned factors are considered, the process of implementing a disease surveillance system is challenging. Triangulation of the data from the review of the scholarly and gray literature and the panel of experts who participated in the workshop emphasizes the importance of surveillance system implementation as a continuing learning process. Lessons learned during the process can be used to shape and fine-tune a continually evolving system. System fit and sustainability play key roles in the implementation of electronic disease surveillance systems.

CHAPTER 5: RESULTS – PRIMARY DATA FROM PERU

Introduction

In this chapter, the researcher describes the proposed implementation model developed to explain successful implementation of electronic disease surveillance systems in Peru. In order to address this aim, the researcher used the theoretical approach of Grounded Theory to collect, analyze and interpret primary data from individuals who had direct experience with surveillance at various organizational levels, The Peruvian model derived from these data was influenced by both the successful and unsuccessful experiences of the research participants. The researcher then engaged in a process of data triangulation using the Peruvian electronic disease surveillance model that emerged from the grounded theory approach, the gray literature review, and findings from the expert consensus workshop. In this chapter the grounded theory approach will be described and findings presented, including the Peruvian electronic disease surveillance model that emerged from the data.

Study Context

Peru is a South American country with almost 30 million inhabitants. It is bordered on the north by Ecuador and Colombia, on the south by Chile and Argentina, on the east by Brazil and Bolivia and on the west by the Pacific Ocean. It is a multi-ethnic country, with Spanish being its main language. The geography of the country is quite diverse with three recognized regions: a narrow and plain coast, highlands with mountain peaks reaching 20,000 feet, and a wide jungle region that covers almost 60% of the country.

Ministry of Health (MOH)

The Ministry of Health (MOH) is the national authority for all health care facilities in Peru, including public and private facilities, social security facilities, and Armed Forces health facilities. At the time of this study, each of the Armed Forces Health Departments functioned separately and would coordinate with the MOH as needed or desired. The General Division of Epidemiology (GDE) was the organization in charge of overseeing disease surveillance for the MOH. Nevertheless, the National Institute of Health (NIH) within the MOH was the main public laboratory in the country. The NIH processed blood and other human samples for the diagnosis of diseases that were under national surveillance when the regional laboratories do not have the capability to test them. The MOH also requested support with laboratory testing when necessary to NAMRU-6. The NIH worked as an organization separate from other health-related organizations and includes a disease surveillance system based on laboratory diagnosis. At the time that data were collected for this study, the NIH surveillance system had not been integrated with the system developed by the GDE.

General Division of Epidemiology Surveillance System

The GDE had established a network across Peru at several organizational levels of surveillance: national, regional, network, micro-network and local. The system involved almost 5,000 reporting units in hospitals, health care centers and health care posts. An electronic tool called NOTI-SP was in place for the mandatory notification of 55 diseases or health related events and a national directive required all GDE sites to comply with notification. Disease surveillance notification reports were typically sent weekly as either individual data or data that had been grouped according to age range. Individual data

reporting refers to the notification of a disease or health-related event for each diagnosed patient who presents to a health care facility. The individually focused reports provided detailed information for each case such as age, residential district, gender, and laboratory data. For instance, dengue fever and hepatitis B were reported individually. Grouped reporting referred to diseases or other health-related data that are summarized according to age groups. This type of reporting is usually assigned to diseases or health-related events that occurred on a more frequent basis, such as acute diarrheal disease or sexually transmitted infections.

The process of reporting involved the reporting staff using NOTI software or paper forms if a computer was not available. The NOTI notification report flowed from the local to the micro-network level and then to network surveillance staff who subsequently forwarded the information to personnel in the regional epidemiology office. Regional office staff consolidated the information and sent it to the national level. At the national level, the data were used to create the epidemiological analysis for the country and produce a weekly bulletin that was forwarded to all surveillance units in the country.

The GDE had developed surveillance subsystems in an effort to acquire more information about certain diseases. The selection of these diseases was based on their public health relevance, such as outbreaks or health emergencies; nosocomial infections; international surveillance; risk factors; HIV/AIDS surveillance; neonatal and perinatal surveillance; Measles, Rubella, and other febrile rash diseases; and Syndromic Surveillance. The syndromes under surveillance for the Peruvian MOH are the following: fever, acute icteric fever, hemorrhagic fever, febrile respiratory illness, fever with neurological symptoms, eruptive fever, acute diarrhea, necrotic skin ulcer, acute anemic

fever, and unexplained death post fever. Each one of these subsystems had a national directive supporting them and involved the collection of information through the use of different forms. Some diseases required the collection of laboratory samples. At the time of this study, the MOH surveillance units had several surveillance systems with which they needed to work.

Sentinel Surveillance System

In addition to the aforementioned subsystems, the GDE has instituted a sentinel surveillance system to improve the timeliness of the information received. This type of surveillance took advantage of an online tool and had been implemented for influenza, other respiratory viruses, and acute severe respiratory infections. By using an electronic tool for reporting data, the information collected could be instantly accessed at the regional and national level, thus reducing the time that it took for information to reach decision makers. The GDE selected 21 sites across the country for the reporting of flu syndrome and 7 hospitals for the surveillance of severe acute respiratory infection (SARI) and mortality due to SARI. Since the intent of the current study was to investigate the implementation of electronic disease surveillance systems in Peru, the GDE sentinel electronic surveillance system was one of three systems included in the study. The other two electronic systems included in the study were the system used by the Peruvian Navy and Peruvian Army.

Peruvian Armed Forces

The Armed Forces in Peru included the Army, Navy, and Air Force. The Navy was the first of the three military services to implement a disease surveillance system. No previously existing mandatory notification system had been in place in any of the

services when the Navy initiated their system. Implementation of the system was made possible through the support of the US Naval Medical Research Unit-6 (NAMRU 6) in 2003. A private company contracted by the Navy developed the electronic surveillance tool used for the Navy's system. The tool enabled reporting staff to send disease notifications electronically by using an Internet connection or by calling a toll free phone number. The data were collected for forty-five conditions (diseases and syndromes), including mandatory diagnoses required by the Peruvian MOH and conditions of military relevance. The surveillance process involved surveillance personnel in initially recording individual and grouped disease cases on pre-coded forms.

In 2012, the Peruvian Navy had 121 active reporting units, which included ships that navigated along the Pacific coast and the rivers in the Amazon rainforest. The Peruvian Army decided to implement a disease surveillance system using this same tool in 2005. By 2012, the Peruvian Army had 153 reporting units across the country. Both the Army and Navy systems were implemented by a surveillance team at the national level, with information flowing directly from the reporting unit to the national level. This national surveillance team was comprised of Peruvian Navy and Army epidemiologists assigned to oversee this process. At the same time, NAMRU-6 created a surveillance hub composed of public health professionals to provide technical and financial support. They also offered office space and logistics for one representative of the Public Health Department associated with each of the Armed Forces. Their presence was intended to provide an environment needed to monitor the system and to facilitate the coordination of the surveillance process within the Armed Forces.

The characteristics of the three surveillance systems under study have been summarized in Table 2.

Table 2: Characteristics of the surveillance systems studied to develop the Peruvian Electronic Disease Surveillance Systems Implementation model.

System	Influenza	Alerta DISAMAR	Vigila COSALE
Institution	Ministry of Health (MOH)	Peruvian Navy	Peruvian Army
Type of surveillance	Sentinel	National	National
Year started	2005	2003	2005
# of surveillance units	52 sites	121 sites	153 sites
Location of the sites	Capital and main cities (urban)	Urban and rural sites, and shipboard	Urban and rural sites
Events under surveillance	Outpatient diagnosis of flu-like syndrome AND hospitalized patients for respiratory syndrome and severe acute respiratory infection	45 diseases and syndromes	45 diseases and syndromes
People covered by the system	Data not available from MOH. Usage rate for hospitals in urban areas in Peru is 65%; usage rate for lower level health facilities in urban areas in Peru is 57% (62).	128,000 people including navy personnel and family members	384,000 people including army personnel and family members
Products of the system	Daily and weekly notification of events	Weekly notification of diseases and syndromes	Weekly notification of diseases and syndromes
Financial support*	Primarily funded by MOH with support of external organizations for training sessions and equipment	Technology**, technical assistance, and training funded and still provided by the US Naval Medical Research Unit 6 in Lima Peru	Technology**, technical assistance, and training funded and still provided by the US Naval Medical Research Unit 6 in Lima Peru

*Costing data was unavailable for any of the systems.

** Technology costs have dramatically decreased last year due to the migration to an open source platform

Definitions of Terms

Throughout this chapter, the researcher will use the term "implementers" to refer to the national surveillance team that led the implementation process and the technical staff from external organizations that supported the process.

The researcher used the term "institution" to refer to the Peruvian Ministry of Health or the Armed Forces; while the term "organization" was used to refer to the organizations within the larger institutions. For the Armed Forces institution, the researcher included the Peruvian Navy and the Peruvian Army organizations in this study. For the MOH institution, the researcher described the General Division of Epidemiology and the National Institutes of Health organizations.

The term "surveillance tool" was used to describe the software or platform developed for the purposes of data collection, transmission and analysis in a disease surveillance system.

The researcher used the term "surveillance unit or site" or "reporting unit or site" to refer to any hospital, health care center, health care post, or military unit that employed one or several health care workers trained to fulfill surveillance tasks in addition to their regular tasks. Due to the extensive scope and depth of the MOH surveillance program, the MOH units had greater personnel capacity to perform surveillance tasks compared to the Armed Forces. However, existing surveillance staff limitations prohibited the dedication of one person exclusively to surveillance reporting tasks. For the Armed Forces, the number of personnel in a given surveillance site ranged from hundreds in a

central military hospital to one combat unit-based health care worker who was in charge of all health and surveillance-related activities in the unit.

Disease surveillance implementation model

The proposed implementation model was developed after extensive in-depth interviews with 34 stakeholders involved with the successful implementation of the influenza sentinel disease surveillance system at the MOH and the mandatory national disease surveillance system at the Peruvian Navy and the Peruvian Army. The interviewees were members of different stakeholders groups: reporting staff, national epidemiology team, regional epidemiology team, high-level administrators, and external technical assistance providers (Appendix L). In-depth, open-ended qualitative interviews took place in Lima and Iquitos, Peru, from February to April 2012. Follow-up conversations were conducted over the phone. In total, 23 interviews were conducted, ranging from 30 minutes to one hour and 50 minutes in duration. The researcher conducted all interviews in Spanish since it was the interviewees' primary language and the researcher was a native Spanish speaker.

Research findings revealed that the successful implementation of an electronic disease surveillance system required the presence of several factors at each of the following levels: a) the administrative level within an organization, b) the national and regional epidemiology team level, and c) the surveillance unit or site level. The analysis of primary data using grounded theory methodology led to themes and concepts that the researcher presented visually in Figure 6.

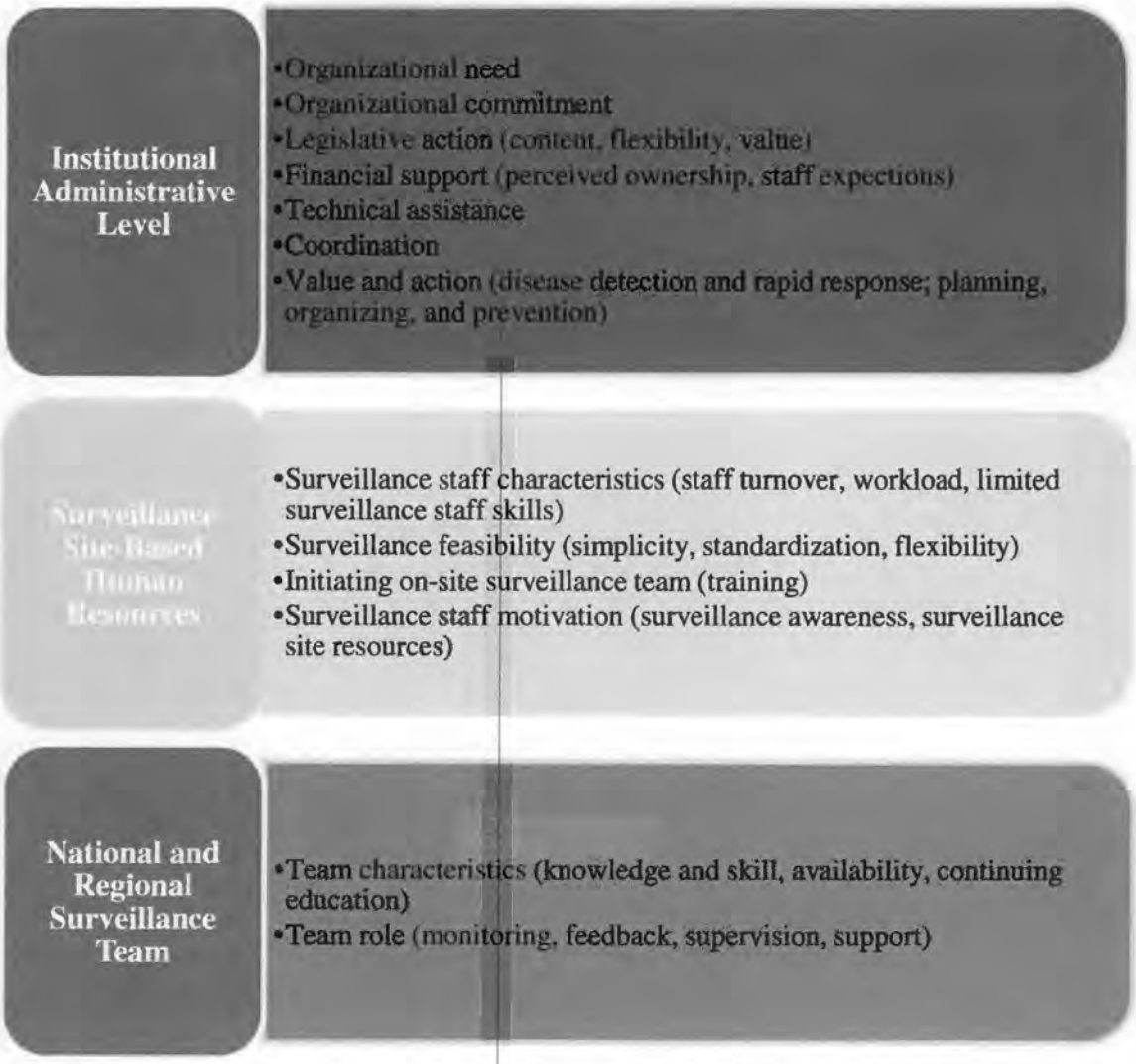

Figure 6: Three implementation levels identified through analysis of primary data using Grounded theory methodology.

Point of Initiation: Institutional Administrative Level

Findings revealed that the successful implementation of an electronic disease surveillance system within an organization initially depended on its high-level authorities recognizing the need for and then committing themselves, their organization, and organizational resources to system implementation. Their recognition of a clear need for

a system tended to facilitate their political will to take action to initiate the system. It was necessary for them to translate their commitment into two related actions that culminated in system initiation and sustainability: a) the generation of legislative action that supported all activities and processes associated with the system, and b) the dedication of financial and other resources necessary to not only initiate, but also sustain the system.

Due to the limited resources dedicated to disease surveillance as well as bureaucratic restrictions on the use of these funds to buy certain equipment or pay for services at government institutions, administrators sometimes sought additional financial support for system implementation through external donors (Int 8, 9). The technical support required for the implementation process came from within the initiating organization or through other international or foreign entities (Int 8, 9). At the administrative level of the organization, it was crucial for high-level authorities to establish mechanisms of coordination between organizations and within the different levels of the system, and to develop collaborative networks across institutions (Int 8, 9).

The outline of the concepts identified at this level is shown in Table 3.

Table 3: Outline of the high administrative level concepts in the Peruvian electronic disease surveillance system implementation model, as identified by the primary data analysis.

Institutional/Organizational need	
Institutional/Organizational commitment	
Legislative Action	• Directive content • Directive flexibility • Directive value
Financial support	• Perceived ownership • Staff expectations
Technical assistance	
Coordination	• Among different organizations within the same institution • Between external technical support and the organization • Between organizations affiliated with different organizations

Institutional/Organizational Need

Rresearch participants reported that any successful disease surveillance system must be developed and implemented in response to a clear need by the target institution or organization. The electronic disease surveillance systems that the Peruvian Navy and Army deemed successful were their first national surveillance systems. The Navy had clearly identified a need for a surveillance system after a malaria outbreak occurred in a remote area of the rainforest. The lack of a surveillance system prevented naval public health authorities from detecting and responding to the malaria outbreak quickly and effectively (Int 2, Int 7, Int 13). The Peruvian Army had similar experiences, mainly in remote areas where their military missions took place (Int 11). For the GDE, the influenza sentinel surveillance system was implemented in response to a pandemic influenza threat (Int 8, Int 9).

Research participants observed, in contrast, that lacking a clear need for a surveillance system could contribute to a failure of a surveillance system's implementation process. For instance, NAMRU-6 offered the same data collection instrument for surveillance that had been successfully implemented in the Peruvian Armed Forces to the Ecuadorian Armed Forces and the MOH in Panama. The surveillance tool was implemented in Panama and Ecuador but later abandoned by both institutions (Int 1, Int 7); in part because both had an existing disease surveillance system and did not entirely depend on the information collected by this tool to make their public health decisions. For the MOH in Panama, public health authorities in that country viewed the NAMRU-6 tool as complementary and designed only to report outbreak situations (Int 7).

Institutional/Organizational Commitment

While organizational need was viewed as a starting point, research participants viewed an organizational or institutional commitment to system implementation as critical. Once an organization or institution demonstrated a clear need for an electronic disease surveillance system, research participants in the study indicated that the next step in implementing a system was to obtain commitment from high level authorities at the organization or the institution where the system would be implemented. These individuals needed to be not only committed to electronic disease surveillance system implementation, but also to the goal of integrating the system into the organization or institution and to developing and implementing a strategy to achieve that purpose.

Two research participants viewed institutional commitment as a particularly important issue when the surveillance system was to be implemented in collaboration

with an external funding agency or through external technical assistance. External funding and technical assistance tended to be time-limited and could contribute to surveillance system failure due to a lack of longer-term sustainability since integration of the system into the organization was unlikely to occur (Int 1). As one research participant explained,

> *De nada sirve implementar un sistema super de vigilancia, si pues el director ni el ministro van a apoyar esto. Sin tampoco el marco normativo correspondiente, porque tiene que estar esto en un marco normativo; sin los mecanismos de financiación también correspondiente. (Int 20)*
>
> [English translation] *It is not of any use to implement a super disease surveillance system, if the director or the minister would not support it. Without legislation that supports the system, because the system has to have supporting legislation. The system also needs the financial mechanisms to function.*

In the presence of organizational or institutional leadership support and a clear awareness of the importance of and need for such a system, research participants believed that commitment to the system could readily be achieved (Int 8, Int 10, Int 3, Int 20, Int 21). For the Armed Forces, however, commitment to implementation presented additional challenges because their leadership often lacked a public health background. National epidemiology officers then faced the challenge of raising the awareness of high-level Armed Forces authorities about disease surveillance and convincing them about the benefits and need for such systems (Int 22).

Organizational or institutional commitment to the system was not only necessary to sustain support for the system, but also to obtain adequate resources, enact legislation

in support of the system, and facilitate key implementation actions or activities (Int 11, Int 13, Int 7, Int 3, Int 15). Implementation actions included seeking approval for personnel to attend training courses (Int 15); developing logistics for training sessions and supervision visits (Int 18); facilitating the logistics for the surveillance processes such as the use of computers for reporting (Int 3); transporting samples to the central laboratory (Int 22); and supporting policies and procedures that needed to be in place in order for personnel to respond quickly and effectively to the disease events detected by the surveillance system (Int 17).

Key leaders sometimes played a critical role in surveillance activities such as training sessions (Int 2) or raising awareness during ceremonial presentations. For instance, during a national training, the Army Surgeon General gave a speech to all personnel about the importance of electronic disease surveillance systems. Research participants in this study believed that the speech contributed to the high morale of surveillance staff and to an increased awareness by line officers and enlisted personnel about the importance of disease surveillance in general (Int 17, Int 21).

If the head of an organization, region, district, hospital or surveillance site was aware of the importance of the system and supported its implementation, it was more likely that staff under his/her direction would follow suit (Int 18, Int 22, Int 23, Int 20). Research participants mentioned examples at every level, starting from the Surgeon General or Minister of Health (Int 20, Int 3, Int 21), and going through the Director of the National Epidemiology Office (NEO) (Int 20, Int 5, Int 22), Director of the NEO Surveillance Office (Int 7), Director of the Regional Office of Epidemiology (Int7, Int 23), and Director of the Surveillance Site (Int 22, Int 3) (Figure 7).

Figure 7: Hierarchy of disease surveillance authorities.

Legislative Action

One of the most important elements needed once the organization or institution's commitment was achieved, was the enactment of legislative action. Several research participants viewed national legislative action to develop a national directive as a key to the success of a surveillance system (Int 1, Int 10, Int 20, Int 23, Int 4, Int 5, Int 8). Developing a national directive based on the legislation was among the initial steps that research participants in the study mentioned in the context of implementing an electronic disease surveillance system (Int 13). Legislation and a national directive meant that health workers and other staff assumed responsibility for performing the identified surveillance tasks. It also signified that surveillance staff could be held accountable for their actions or inactivity once they had been provided with the tools and training to use the electronic surveillance system (Int 13, Int 2, Int 8).

For military organizations, a directive also represented a tool that implementers could use to position the system as an integral part of the organization. The dissemination of these documents to all the surveillances sites was important to ensure that the commanders at the sites provided the support to the surveillance staff for the fulfillment of the surveillance tasks described in this document (Int 2, Int 4). One research participant associated system failure with a lack of national legislation or a directive

regarding a disease surveillance system in the Armed Forces in Ecuador (Int 1). According to three research participants, it would be difficult to find the support needed to execute the activities required for surveillance system implementation in the absence of legislation or a directive (Int 1, Int 10, Int 9).

Content

As important as it was to have legislation and a national directive, research participants believed it was equally important to include clear and precise guidelines within the directive (Int 23, Int 7). In their view, the directive should specify the system's components, all the steps of the disease surveillance processes, and the resources required to accomplish all surveillance tasks (Int 10, Int 20, Int 2, Int 8, Int 9). They underscored the necessity for implementers to follow the directive. They should, for example, design surveillance activities according to what was described in the directive (Int 9). If it was not written in the directive, support for necessary surveillance activities was difficult to marshal (Int 6). On the other hand, when a task was included in the directive, surveillance staff would be able to request the resources required for implementation. Such resources might be, for example, computers for use in an information technology (IT) department (Int 4). In addition, national or regional surveillance team leaders could reference the legislation or national directive when sending congratulatory messages to personnel who had exhibited exemplary work performance. Such congratulatory messages served as a means of acknowledging excellent work and as a potential motivator for continued employee excellence (Int 21).

Flexibility

Research participants observed that flexibility and responsiveness to change in disease surveillance systems and in the directive or legislation that guided them would

facilitate the implementation process. A change in the public health situation in Peru, for instance, may necessitate a change in the country's disease surveillance system. Once a directive was published or legislation enacted, therefore, system implementers had to be able to adapt it to changing circumstances in a timely manner (Int 1, Int 9).

Value

The existence of legislation related to disease surveillance virtually guaranteed continuity in the organization's commitment. Regardless of changes in high level administrative positions, for example, existing legislation or a directive meant that established disease surveillance priorities would continue to be maintained and supported (Int 1, Int 3, Int 5, Int 7).

Financial Support

The second key element that could be obtained in support of a system, given institutional or organizational commitment, was financial support. Research participants identified the designation of adequate financial resources in the implementation of a surveillance system as a critical need. Ideally such resources would come from the organization where the system was to be implemented (Int 10, Int 20). However, due to the limited resources for disease surveillance in countries like Peru, it was common for disease surveillance systems to be implemented with the financial support of an external donor (Int 13, Int 11, Int 18, Int 2, Int 5, Int 1, Int 6).

Regarding the commitment of the organizations to invest in disease surveillance, the Armed Forces faced a different situation than that which was faced by the MOH. Military organizations claimed national security as their number one goal, not health. They therefore designated a very small part of their budget to health with an even smaller

piece of it going to preventive medicine (Int 11). The military organizations used external funding to develop their first and only national surveillance system (Int 11, Int 13). Without this economical support, they could have not afforded an electronic tool, and the many resources that the implementation process required such as the cost of training and supervision (Int 11). Armed Forces authorities claimed they did not have money available to buy equipment such as computers and pay for Internet services. They relied on external funding to buy the equipment they needed for surveillance purposes (Int 6).

For the MOH, the challenges were different. They had a budget assigned for these activities. However, their budget was limited, especially for buying the required equipment. Of necessity, external organizations, such as the Pan American Health Organization (PAHO), continued to provide funding for equipment, training, logistics, laboratory supplies, infrastructure, and the hiring of personnel (Int 9, Int 23, Int 13). Moreover, the process to buy equipment, even small equipment such as printers, was extremely lengthy and tedious (Int 23). Surveillance staff had many administrative steps to follow in making such purchases and the process sometimes took more than one year (Int 9). Therefore, surveillance supervisors who developed the surveillance tools for the system often faced limited technology when striving to have the system ready when it was needed (Int 8).

Research participants' major concern about the external funding of surveillance systems was that such funding was typically costly and of limited duration. For instance, the expense entailed by hiring a private company to develop, test, implement, and periodically revise a surveillance instrument for the Armed Forces was assumed by NAMRU-6 for a decade. After 10 years, however, the continuation of the external

funding became unsustainable, the Armed Forces were not able to afford the cost, and a solution was needed. In this case, data from the original tool were able to be collected by means of an open source tool. In the end, the disease surveillance system was sustained only by exercising the option of accessing a free tool (Int 12, Int 1, Int 11).

Perceived Ownership

When external organizations supported the implementation process of a disease surveillance system, successful implementation depended, in part, on system staff perceiving ownership of the system (Int 14). If members of the surveillance team believed that what was asked of them had originated from an external organization, one research participant indicated that such individuals might feel less compelled to complete the assigned tasks (Int 3).

Staff expectations

In the case of foreign organizations' involvement in supporting the process of disease surveillance implementation, the staff recipients of their support had expectations that "gifts" would accompany the surveillance "project." These expectations occurred due to a long history of how foreign organizations worked in Peru. Foreign organizations had been primarily interested in studying a specific disease and their projects had funding to buy equipment required for the project. This equipment typically stayed in the country after such project ended. Such "gifts" might have included computers and printers for staff use at the surveillance site (Int 2). Therefore, it was important that the organization delivered to staff a clear message of system ownership, making sure the surveillance staff understood that rather than being externally owned, the system that received external support belonged to the organization.

Technical assistance

In addition to financial support of the system, another consideration at this level was the need for technical assistance. Organizations such as the MOH had extensive experience in disease surveillance, but were open to receive technical support from other organizations such as PAHO and CDC. In the case of electronic disease surveillance program technical support, it was the Armed Forces that experienced the greater need, to which the Peruvian MOH and external organizations such as a NAMRU-6 responded.

If an external organization provided technical assistance for the surveillance process, a research participant raised the point that the aim of that organization should be to build capacity within the recipient organization in order to develop a team that ultimately would be able to lead the implementation process (Int 7). Technical support should continue to the point that the organization was able to administer the process independently (Int 7).One research participant, for instance, considered the implementation process a failure, *"el sistema fracaso,"* when the organization took over the surveillance process prematurely (Int 7).

Coordination

Those who participated in the study indicated that system coordination had to be clearly defined and established at the highest administrative levels within institutions and among and within organizations that were a part of institutions. Institutions such as the MOH had several organizations that worked with disease surveillance, including the DGE and the NIH that recognized the need to improve their collaboration. Furthermore, a need existed for the coordination of efforts within individual organizations. Disease surveillance functions within DGE, for example, were structured into several groups of

diseases under surveillance such as zoonotic diseases, vaccine preventable diseases, diseases transmitted by vectors, and others. Research participants believed that these groups would have benefitted from coordinating their surveillance activities.

Once a system was developed, strategies had to be developed to enact the coordination of work at the different levels of the disease surveillance network. Therefore, the task at the highest administrative level was to establish and disseminate the coordination mechanisms across the organizations within the same institution by involving groups at different levels within the same organization. It was also critical that institutions developed partnerships with other institutions in order to enhance their surveillance capabilities.

Among different organizations within the same institution

Several organizations affiliated with the Peruvian MOH used different surveillance systems to provide epidemiological surveillance data, including laboratory and public health data. Although each surveillance system collected information from the same patients, at the time of this study the systems did not share the same data (Int 10, Int 5). Research participants identified one of the key elements in the sustainability of disease surveillance as the coordination of and eventual integration of these disparate systems in order to meet the need for timely and more complete surveillance data (Int 9). They believed that effective communication channels had to be established among organizations within the MOH. A research participant offered the following comment:

> *En el Ministerio de Salud tenemos dos, uno de nosotros, de lo que es la notificación en línea, [....] y estamos ahorita trabajando una plataforma, pero necesitamos un campo en común, que pueda permitir jalar la información de*

laboratorio y viceversa, la información epidemiológica, los laboratorios y no estar digitando la información de las fichas en dos lugares diferentes. (Int 9)

[English translation] *In the Ministry of Health we have two [surveillance tools], one that is the online system [....] We are now working on a platform but we need a field in common, that allows us to pull the laboratory information and vice versa, the epidemiological information, the laboratory information, and not have to enter information on the forms in two different places. (Int 9)*

Between external technical support and the organization

Research participants observed that the facilitation of on-going communication between technical support staff situated outside the organization and surveillance personnel located within the organization was key to maintaining an effective problem-solving environment. They contended that even when communication channels were established, true collaboration only occurred when personnel from disparate areas worked closely together at the onset of a particular surveillance process. In any collaborative effort it was important to appoint a process technical leader in conjunction with assigning roles within the work team (Int 12).

It was quite important to develop a relationship of trust between members of the external funding organization and organizational personnel that facilitated positive working relationships. In Peruvian culture, it is culturally important to become friends before becoming business partners (Int 7). Research participants described occasions when tasks or goals were not accomplished because of a lack of coordination of efforts or political disagreements (Int 10, Int 11, Int 3, Int 12, Int 8). They related successful system

implementation to people being able to listen to an experienced counterpart and to making joint decisions (Int 7, Int 12).

Between organizations affiliated with different institutions

For surveillance staff in military organizations it was critical to establish a collaborative relationship with the MOH, and especially imperative for sites located outside the capital of the country where mutual support could be offered if disease outbreaks occurred. Research participants foresaw that the MOH and Armed Forces surveillance systems would ideally be integrated at some point in the future (Int 14, Int 15, Int 11, Int 4).

The concepts and relationships at the high administrative level are summarized in Figure 8.

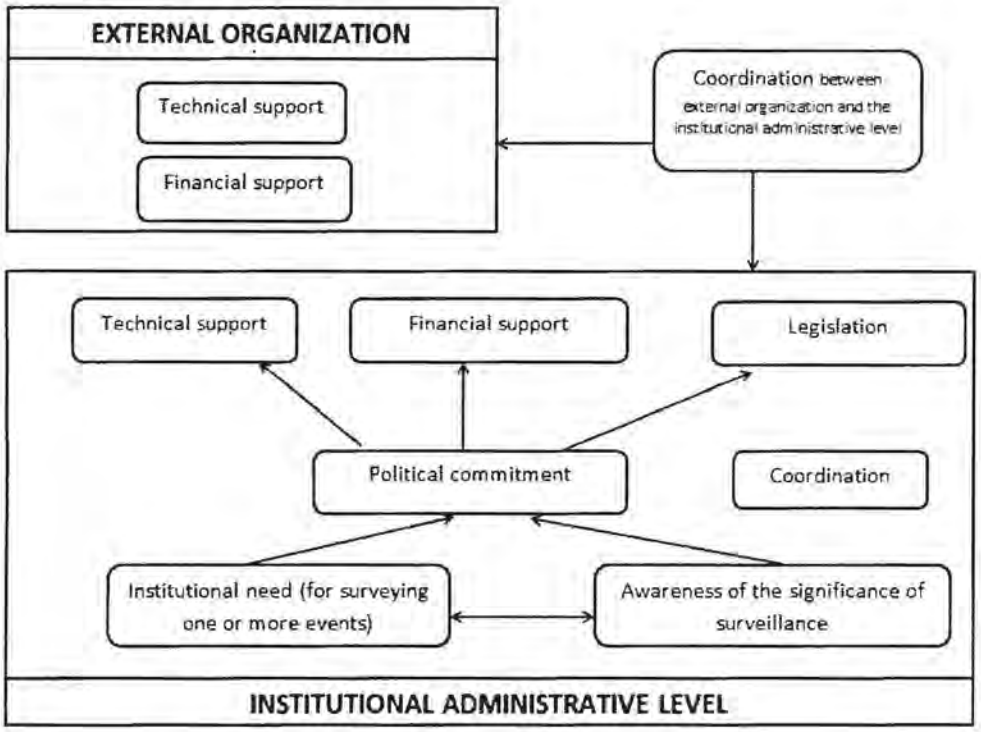

Figure 8: Institutional administrative level.

Surveillance site-based human resources

The second level identified in this model was the surveillance site. As described earlier, a surveillance site was a health care facility or a military unit that had among their staff a health care worker trained to fulfill surveillance tasks. At this level, the human resources were identified as the key element for the success of the surveillance process. In this section, the researcher will describe the concepts identified that enabled the high performance of the surveillance staff as well as those that created the greatest difficulties in their work.

While the support of high level authorities was viewed by research participants as critical to start the surveillance implementation process, without human resources at the surveillance site that were skilled and motivated, a disease surveillance system could not be initiated and would not be able to function. Based on findings that emerged from this study, the model for successfully implementing an electronic disease surveillance system in Peru included human resources as a fundamental component. In this section, the researcher will explain human resources needs at the surveillance site level and will describe the elements required at the surveillance site and the national and regional levels to ensure the availability of adequate human resources. The sentiments of several research participants about the importance of surveillance personnel were captured by the following research participants' comment:

> *y pensar siempre que el sistema opera gracias a las personas que están en las unidades notificantes, ellos son los elementos clave para el éxito del sistema. (Int 21)*

[English translation:] Always think that the system works because of the people in the surveillance sites; they are the key elements for the success of the system. (Int 21).

The outline of the surveillance site level concepts is depicted in Table 4.

Table 4: Outline of the surveillance site level concepts in the Peruvian electronic disease surveillance system implementation model, as identified by the primary data analysis.

Surveillance staff characteristics	• Staff turnover • Workload • Limited knowledge and skills
Surveillance feasibility	• Simplicity • Standardization • Flexibility: ▪ In responsiveness to changing needs ▪ In reporting deadlines ▪ In reporting expectations ▪ In means of communicating reports ▪ In the surveillance tool
Initiating on-site surveillance teams	• Training ▪ Target ▪ Context ▪ Delivery strategies ▪ Type (continuous and comprehensive) ▪ Train the trainers approach ▪ Institutionalization of training
Surveillance staff motivation	• Surveillance awareness • Surveillance site resources ▪ Availability ▪ Administrative support ▪ Performance-based access ▪ Existing resources use ▪ Incentives ▪ Training as motivator ▪ Accountability

Surveillance Staff Characteristics

Surveillance staff in the systems studied always included, at minimum, a health care worker at the health care facility or military unit. Surveillance tasks are primarily conducted by nurses or military nurses (nurses who had received their education throughout the Armed Forces rather than a traditional college). However, young physicians as well as nurse technicians were trained to conduct surveillance tasks as well.

As mentioned earlier, depending on the size of the facility, surveillance staff could vary from only one person in most of the combat units to several workers at larger facilities.

Research participants associated the development of a skilled, motivated surveillance staff with three main challenges: staff turnover, workload issues, and skill level. Each of these challenges will be discussed in the following section.

Staff turnover

Several participants in this study observed high surveillance staff turnover as a challenge that affected both the Armed Forces and the MOH surveillance programs but was noticed to a greater degree in the Armed Forces (Int 11, Int 16. Int 19, Int 21, Int 23, Int 9). Personnel in the Armed Forces were rotated once or twice a year across the country. New personnel coming to the site may not have been trained or have less motivation to perform surveillance tasks. A change in personnel would then affect the surveillance performance of the site. Turnover was more commonly experienced by personnel assigned to surveillance sites outside of the capital (Int 11). Since the rotation of personnel closer to the cities served as an incentive for health care workers and was a change that surveillance personnel in more remote sites frequently sought (Int 23), administrators awarded the best performing staff by reassigning them to the more coveted surveillance sites closer to cities.

Workload

Research participants noted that the number of personnel assigned to work on surveillance was typically insufficient (Int 10, Int 22, Int 23). Furthermore, one of the biggest challenges organizations faced in general was hiring new personnel because of limited budgets (Int 9). Participants contended that health care workers were over-worked

due, in part, to frequent assignments of tasks over and above the patient care for which they were responsible. For them, surveillance tasks represented the addition of more activities without them deriving additional benefits including salary increases (Int 10, Int 23, Int 13). Making the situation even more challenging were the different types of surveillance conducted at any given site that were implemented for different diseases, thus overloading surveillance staff and their supervisors (Int 3, Int 10, Int 15, Int 16, Int 17) with data collection and reporting responsibilities.

Research participants observed that when surveillance staff, including health care workers, had many other activities to perform, they were less likely to collect and report surveillance data (Int 2). The participants described the difference in the performance between a site with surveillance personnel supported by an external organization that enabled staff to be exclusively dedicated to surveillance tasks and a site without external support whose personnel had multiple tasks to fulfill in addition to surveillance (Int 10). An example of the latter site was one affiliated with the MOH. As might be expected, the site with the personnel exclusively dedicated to surveillance tasks collected better quality data and did so in a more timely way.

Limited surveillance staff skills

Having previous experience working in the area of disease surveillance reduced staff members' adaptation time to new surveillance tasks. Research participants with experience in using alternative surveillance system(s) shared the view that their prior experience with a system made it easier for them to transition to using a new surveillance tool (Int 3). In military organizations in Peru, most of the health care workers were unfamiliar with the disease surveillance process and the role they might be expected to play in that process (Int 1, Int 17).

When involved in surveillance, health care workers had to incorporate the new surveillance tasks into their other daily tasks and begin documenting all required disease-related information for their patients or clients in a log book or other record (Int 4). In addition, they had to learn new information such as the definitions of the diseases and the specific disease-related data or events that were being surveyed (Int 4). Research participants said that one of the issues that health care workers faced was a lack of or limited knowledge about epidemiology and disease surveillance. They related this limitation to the education of health care professionals in schools where little emphasis was given to public health or disease surveillance (Int 13, Int 15, Int 9).

The implementation of a new surveillance tool was accompanied by a sometimes-steep learning curve, depending on the complexity of the tool. Research participants commented that the likelihood of staff errors in data collected and reported was increased at the beginning of tool use. National surveillance team members worked to correct these errors by communicating with staff new to the process, often by telephone (Int 17). However, once personnel had used the tool for about two months, they gained facility with the tool and using it became more error free (Int 10, Int 16, Int 17, Int 22). Research participants suggested that having staff with prior experience in surveillance data collection enabled these individuals to gain expertise in using a new surveillance tool more rapidly, typically within about one month (Int 3).

Taking into consideration the challenges of frequent staff turnover, staff workload, and limited staff surveillance skills, making the electronic disease surveillance task feasible was recognized by research participants as an important strategy in system implementation. Surveillance feasibility included designing flexible and simple

surveillance processes and creating a surveillance team at the site. In order to assure a skilled surveillance workforce, the implementation of a training strategy was critical. And finally, in order to increase the motivation of the health care workers, implementers needed adequate resources, incentives, and support from direct supervisors at the surveillance site.

Surveillance Feasibility

Study participants understood that the effectiveness of a surveillance system depended on two important things for initiators to keep in mind: avoiding surveillance staff work overload and making surveillance a feasible task (Int 11) in terms of the processes and tools employed. Ensuring feasibility involved ensuring simplicity, flexibility and standardization of both processes and tools, each of which will be discussed in the following section.

Simplicity

Surveillance processes needed to be as simple as possible to enable surveillance staff to meet expectations and avoid disruption of their other assigned activities (Int 11, Int 8). Research participants explained that surveillance systems tended to fail in the presence of two problems: a) the system or its component processes were too complex or b) administrators or others held unrealistic expectations for collecting a great quantity of information that ultimately proved to be impossible for staff to manage (Int 7). The latter problem was exemplified by one research participant's account:

> *Tuvimos la oportunidad [....]de poder implementar otro sistema de información....., quisimos hacer lo mismo; nosotros pusimos cosas sencillas para colectar la información, pero el comando de turno en ese momento, quería*

meterle más información; quería que ese sistema cargue toda la información posible y eso no lo hizo viable, a través del tiempo no pudimos implementar eso, porque se quiso recoger miles de variables para que al final no se analice nada. Entonces si nosotros tuviéramos que implementar variables sencillas, creo que hubiera sido más fácil. (Int 7)

[English translation:] *We had the opportunity [....] to implement another surveillance system. [.... but] we wanted to do the same [one]. We used simple means to collect the information, but the command at that time wanted to add more variables to be collected. They wanted the system to collect all the information possible and this was not viable. We could not implement this because they wanted to collect thousands of variables. We were not able to analyze anything [because the system did not work and did not collect any information]. If we had implemented simple variables, I think it could have been easier. (Int 7)*

The participants believed that some aspects of a disease surveillance system could be simplified in an effort to contribute to the potential success of the system (Int7, 22). Such simplified efforts could result from a planning process that resulted in focused, simplified, and feasible surveillance efforts (Int 7, 8). As part of this effort, strategies such as simplifying data collection instruments, reducing report frequency, and simplifying training efforts could potentially contribute to the success of an electronic disease surveillance system.

When determining the magnitude and type of surveillance data to be collected, for example, research participants suggested that consideration be given to several issues: the

need for the data and how data would be used, the resources available, the data collection process to be employed, the complexity of data collection forms, the kind and complexity of data analysis (Int 8, Int 22), and the frequency of report submissions (Int 14). Sometimes the change needed was reportedly the simplification of an instrument. Two research participants commented that it had been necessary for them to change a three-page form used by a surveillance system to a much simpler one-page form in order to make it easier for end users of the form to collect data (Int 22, Int 9). In addition to facilitating data collection, simple, user-friendly surveillance tools were noted by the participants to facilitate data reporting for end users as well (Int 16, Int 8, Int 20). Moreover, two research participants suggested that user acceptability could be enhanced by having a simple tool that users could quickly load onto every computer, even those with slow Internet connections (Int 8) that, at the time of this study, were quite common in most areas outside the capital.

Report frequency and type (individual versus grouped) sometimes posed issues for surveillance systems implementers in terms of the timely receipt of data. In one circumstance, time constraints and competing tasks necessitated a change in the frequency of grouped report submissions required of surveillance sites (Int 14). In another situation, disease surveillance processes become more challenging in the face of a disease outbreak or a disaster since the incidence of affected cases increases quickly and often substantially (Int 8). In anticipation of this situation, a national surveillance team decided to change their requirements and request a grouped rather than individual case report for future disaster situations (Int 8). Thus, simplifying the reporting schedule

that could involve reduced frequency of reporting or changing from an individual to a grouped report could yield positive results.

Research participants were clear about the need for simplifying training resources in an effort to make them more relevant and concise. Some research participants shared personal experiences associated with their efforts to explain surveillance processes to surveillance staff. In a training session recounted by one research participant, for instance, the surveillance team developed a detailed manual to guide the process. Users, however, found the manual to be too complex and detailed to be particularly useful. Implementers learned that providing a simple summary of processes and guidance for reporting events was far more acceptable to surveillance staff than a large, highly detailed manual (Int 7).

Standardization

Research participants asserted that every surveillance process had to be "well mapped" (Int 20, Int 7). In general, research participants in the study observed the importance of standardizing the processes to collect and report data at every surveillance site, both military and civilian, and, when possible, adapting the processes to the tool used to report the data (Int 17, Int 22, Int 3, Int 4). In the case of modifying the surveillance tool, for instance, one research participant shared an example of health care providers at surveillance sites registering patient visits by handwriting patient's names and vital signs in a logbook that was ultimately used to extract information for reporting (Int 14). When febrile syndrome cases were added to the surveillance list, a column was added to the logbook so health care providers could record the patient's fever if present (Int 14).

Research participants shared the intention that processes be standardized in every location where patients had initiated contact with a health care facility such as emergency rooms, ambulatory offices, and hospital admissions (Int 22, Int 3, Int 20). However, one of the problems that research participants observed was data consistency: not every site recorded the same data in their books (Int 4). In some cases, patient data or events that were required to be collected were listed on a reminder card as well as on the document where the data were recorded. Health care providers, however, continued to be confused about the specific data that they needed to report (Int 14, Int 5, Int 13). For instance, personnel were aware of the need to report febrile cases but were not clear about the level of evidence needed to determine fever. They were uncertain if they needed objective evidence of fever or could accept their patient's self-report of fever (Int 14) as reportable data. They were also unclear about the designation of new cases, as illustrated by a circumstance when a patient made a return visit for the same complaint (Int 18). Accordingly, research participants recommended that data collection guidelines clearly specify the parameters of data to be collected and reported (Int 5).

Flexibility

Participants in the study identified flexibility as a means of adaptability that served as a key attribute of successful electronic disease surveillance systems. They addressed concerns about flexibility in several areas: responsiveness to changing surveillance needs; reporting deadlines; reporting expectations; means of communicating reports; and modifications of the surveillance tool. They also suggested changes in the report accountability process.

Several research participants shared their experiences with surveillance systems in other countries by describing the importance of flexibility not only when developing the

disease surveillance tool, but also throughout the entire process of implementation. One research participant, for instance, noted that surveillance actors with an inflexible vision of the system could jeopardize the implementation process (Int 7). This individual highlighted the importance of flexibility from every person involved in the surveillance process (surveillance staff, supervisors, authorities, funding organizations) and during each part of the implementation process (Int 7).

Responsiveness to changing surveillance needs

Research participants underscored the need for a disease surveillance system to be adaptable to different epidemiological scenarios and international recommendations. One research participant recalled that an influenza surveillance system proved its adaptability by its ability to incorporate new WHO recommendations when the system had already been functioning for a year (Int 9). This participant also recalled the threat of pandemic influenza in 2003 and the initiation of preparedness for it, although the health problem did not actually occur until several years after. The experience enabled surveillance personnel to develop several plans to respond to future possible scenarios in terms of training and resources (Int 9).

Another research participant shared the case of a laboratory surveillance system flexible enough for a surveillance team to add surveillance for other health-related events such as respiratory viruses and microbial drug resistance (Int 5). Flexibility included legislation as mentioned in the context of a need to modify laws or regulations in order to take into account differing needs for information. When the influenza situation was under control, for example, legislation was modified to continue to provide needed information, but also to make data collection more feasible for the surveillance staff (Int 8, Int 9).

Reporting deadlines

Research participants at the surveillance staff and national surveillance team levels emphasized the desirability of having some flexibility in deadline dates and times for surveillance reports. Due to limited resources at many sites, study participants agreed that reporting deadlines should be adjusted to reflect what was feasible at various surveillance sites. Research participants, for example, expressed appreciation for the change in report frequency from twice per week to once per week. They also appreciated a change in the reporting deadline time. A change in time from noon to midnight (Int 14) on Mondays was helpful because it allowed more time for report preparation on a day of the week that participants experienced as particularly busy (Int 15, Int 16). The reasons given to justify the deadline extension included limited staff, efforts to attend to competing tasks, slow Internet connectivity, availability of the records log(s) used to complete the report, and the availability of a means of communication used to send the report (Int 16).

In reporting expectations

Participants in this study recognized differences among surveillance units and commented that various units with differing levels of resources, including communication resources and expectations for travel, should not be held accountable to the same standards. There were surveillance sites located proximal to a large city that had all means of communication with surveillance staff who were not assigned to conduct surveillance missions external to the site (Int 4, Int 14). For these sites, reporting did not represent a great burden when compared to some sites that regularly undertook military missions. According to one participant, the surveillance staff at one of these latter sites would inform their supervisors that they were traveling on a military mission to a remote area and would have no dependable access to a means of communication. The staff

would then update the reporting once they returned (Int 15). Flexibility in reporting deadlines was typically granted to units deployed to areas of conflict (Int 16).

Surveillance reporting

Research participants identified flexibility in the means of communicating the surveillance report as a key element that contributed to the success of a surveillance system. In developing countries, surveillance personnel from many geographical areas without access to computers, the Internet, or landline telephones had to use other means of communication such as a radio.

Research participants mentioned different communication modalities they used to report their surveillance data. Depending on availability, the modalities included using a computer with Internet connectivity or a landline phone, a public pay phone, or a mobile phone using a toll free number (int 12, int 14, int 15, int 16). Flexibility in these modes of communication allowed members at higher levels of the surveillance system to reach surveillance staff in towns or other areas where Internet access was unavailable and public pay phones were distant from surveillance units (Int 16, Int 19, Int 21). Surveillance personnel were able to transition from using public pay phones to using the Internet when Internet access became available at their sites. They found that reporting using a computer was easier than using a telephone (int 17, int 4). Furthermore, participants noted that surveillance personnel at some sites would use the radio to communicate surveillance data to a site that had direct access to the system's electronic surveillance tool. Staff on the receiving end of the radio communication could then enter the information electronically into the surveillance system as directed by the individual on the other end (int 6). A participant offered the following comment about communication alternatives that have evolved.

Nuestro reporte ha sido 100 % porque buscábamos la forma de reportar todo lo que tenía que ser, por Internet o por teléfono público, y se daba cumplimiento porque dentro de la base había teléfono público si es que no había Internet y [....] se ha adicionado lo que es el teléfono móvil, también resulta mucho más sencillo reportarlo en cualquier momento y en cualquier horario que podemos. (int 14)

[English Translation:] Our report is 100% because we looked for the way to report the information, by Internet or by public pay phone, and we will do it because within the (military) base there was a public pay phone in case there was not Internet (access) and [.....] now that we can also use mobile phones to report, it is easier to do it at any time. (Int 14)

Surveillance tool

Three military-affiliated research participants shared with the researcher that the military-operated disease surveillance system included a mechanism to obtain user's requests for surveillance tool modifications. The surveillance representative for each of the Armed Forces could contact the developers of the tool with a request for modification. The surveillance technical assistance team assessed such requests, including the need for a given change to be applied to one of the Armed Forces or across the military services in general. Requests were assigned a priority level for future development and implementation (Int 12). For instance, the Armed Forces requested that trauma events be recorded in their existing surveillance system. These events were then incorporated into the list of surveillance diseases or conditions due to the importance of having this information for use by the Armed Forces in contrast but not by the civilian population (Int 4).

Research participants underscored the importance of implementing approved changes to the instrument in a timely manner. Their inability to see evidence of timely changes in the tool led them to believe that the performance of the surveillance system was compromised, even when they were given feedback to suggest otherwise (Int 21). Having a team of engineers as part of a surveillance team to assess and respond to requests for changes not only improved the flexibility of the tool, but also improved the timeliness with which the team responded to such requests (Int 12).

Initiating on-site surveillance teams

Due to local human resources constraints, the national surveillance team learned that it was important to create a surveillance team in every unit (Int 9, Int 10, Int 13, Int 14, Int 16). They knew it was unrealistic to expect that one person could be dedicated exclusively to surveillance (Int 15). Therefore, having multiple people engaged in surveillance efforts (int 16) eased the overall impact of the task and enabled personnel to comply more effectively with surveillance expectations (int 17, int 19). When the team worked together, the system worked well (Int 3). One person was assigned responsibility for disease surveillance, but everybody at the site collaborated in the event that help was needed (Int 3, Int 17, Int 19), especially when the site was large (Int 4).

Research participants noted that some sites organized the surveillance process by assigning one person to lead the disease surveillance report each week (Int 18). They found it was important to identify and recruit those health workers who seemed more interested in the system (Int 23) and who would be able to disseminate messages about the importance of the system (Int 14). On the other hand, research participants observed

that nurses who had not been trained in the system (Int 16) would not get involved in surveillance activities even when there was suspicion of a disease outbreak (Int 14).

Surveillance site team research participants widely recognized training as one of the most important activities when implementing a disease surveillance system. The key outcome of disease surveillance was to have access to reliable and timely information in order to make decisions (Int 14, Int 15, Int 3). Therefore, human resources needed to be motivated and trained in order to be able to effectively and efficiently collect and transmit this information (Int 13).

Training

At the time of this study, health care workers in Peru had a treatment focus in the area of health and very limited training in public health, epidemiology, or disease surveillance. Surveillance implementers worked on changing the focus of surveillance staff to preventive medicine where they would value preventing the occurrence of diseases rather than waiting for onset of disease that then necessitated treatment (Int 13). A participant underscored the importance of surveillance staff training in the following comment:

> *Mientras la capacitación sea mayor, entonces los reportantes tendrán las herramientas para un mejor reporte y para educar al personal de la importancia del reporte. (Int 16)*
>
> *[English translation:] If there is more training, then the surveillance staff will have more tools to do a better reporting task and to educate the personnel in the importance of surveillance. (Int 16)*

Research participants suggested that opportunities be created to train as many personnel as possible despite the limited resources available. They made the following suggestions:

1. Offer joint training across organizations in order to achieve reduced training costs and aid in establishing coordination mechanisms among the Armed Forces in cities. In that way, collaboration in responding to health related emergencies would be facilitated. (Int 15).

2. Conduct training courses across all Armed Forces in cities where more surveillance sites were located (Int 15).

3. Reduce training time to a one-day course. Address concepts on surveillance during a half-day session and enable trainees to practice applying the concepts during the remaining half day. At one time three-day training courses were offered but a one-day course afforded trainers two additional days to be devoted to supervising accessible sites (Int 15).

Target

External developers or individuals from within the institution with surveillance expertise initiated training for the purpose of orienting surveillance personnel to new tools or systems and for the purpose of retraining personnel when necessary. Training that ultimately reached all surveillance levels, district, regional and central, was most likely to yield successful implementation of a system (Int 20).

According to research participants, implementing a new tool or broader surveillance system was typically accompanied by initial training at the central level in either the Armed Forces or the MOH. Once training of the central level team was completed, training was instituted at the regional level (Int 23). Staff at the central and

regional levels then joined forces to train district-level end users. If an external group provided initial training, this group made themselves available for clarification or support during the initial phase of system implementation (Int 7, Int 23).

Context and content

Trainers had to consider their audience when developing the content of their surveillance training courses (Int 20). Health care workers and other professionals differed in their expectations of and need for a particular depth and scope of information provided and the language used in presenting information. When communicating with high-level authorities, for example, the designers of the training experience paid attention to institutional context such as the Armed Forces, where the highest-level health authorities did not have a medical background.

Instructional designers thus had to tailor the training content and terminology to ensure a clear understanding of disease surveillance by non-health professionals. A research participant provided an additional example of tailored training related to the increasing reliance of disease surveillance systems on technology. Adapting the training was sometimes necessary to meet the needs of senior personnel who typically had less experience with technology than younger trainees. Their training sometimes involved a greater allocation of time for learning (Int 20).

Delivery Strategies

Research participants described two primary strategies used to deliver surveillance training: a) large-scale training at one location which required attendees from different geographical areas of the country to travel to the training site, and b) combining training by surveillance supervisors with scheduled on-site supervisory visits to surveillance units. At the time of this study, high-level administrators were considering

a third training strategy that involved using an on-line environment, but such training had not been implemented in the country on a scale beyond e-mail communication with staff. As mentioned earlier, on-line training was hindered by a lack of, or problems with, consistent Internet access and, for some personnel, a lack of computer access.

Participants observed that a fundamental problem that necessitated the training of surveillance personnel was a lack of disease surveillance education offered to health care workers in their pre-professional preparation programs. Barriers to larger scale, centrally offered trainings included a lack of resources to fund attendees' travel. In the case of combining training with supervisory visits, barriers arose with a lack of staff time to devote to travel, especially to remote sites, for supervision as well as training. Staff turnover also posed problems since basic level training had to be continuously offered, particularly at more remote surveillance sites.

Surveillance staff training was mainly conducted at a central or regional location, which meant surveillance staff members from all areas of the country were invited to participate in these training courses (Int 17). Research participants described one of the benefits of this type of training in terms of its importance in establishing relationships between and among system supervisors and reporting staff. Participants commented that the experiences shared during the training helped supervisors and surveillance staff develop closer relationships, which was essential for future communication about the system. Relationship building also increased staff motivation to comply with disease reporting guidelines (Int 9, Int 10, Int 15). In addition, research participants believed that the presence of a high-level authority at the beginning or end of a training course

emphasized to attendees the importance of disease surveillance. The presence of the authority at the training also could be motivating for trainees (Int 18).

Bringing surveillance personnel to a central location for training was usually possible only with external funding due to the high costs of travel (Int 8, Int 15). Even with the availability of funding, surveillance site personnel often found it difficult to absent themselves from their site for any length of time.

Aside from the resource-intensive large-group one-site trainings that required attendees to travel, training also was undertaken as a part of periodic supervisory visits to surveillance sites. Supervisory visits to surveillance unit personnel were resource intensive due to limited numbers of supervisors and expenses incurred with supervisors' travel and time. According to research participants, the resource intensive nature of supervisory visits led to such visits serving two purposes: the provision of oversight of personnel and engagement of site supervisors in personnel training. Supervisors provided training or retraining, and worked with staff to resolve issues that hindered adequate site performance (Int 15, Int 9).

Online surveillance training was an additional training option that was under consideration at the time of this study. There had been some support for and efforts toward providing online training to surveillance personnel, though such training had not been implemented (Int 11). Participants expressed the belief that an on-line training option would be beneficial, particularly as a means of addressing resource constraints and allowing more flexibility for participants to attend trainings. Participants explained that surveillance supervisors used email and telephone communications to reinforce the training that personnel had received and had found that email messaging, for example,

was a useful way to clarify staff doubts, send documentation and information, as well as establish permanent contact with surveillance staff being supervised (Int 15). One problem however, was the continuing high rate of staff turnover at surveillance sites, thus presenting a continuous need for basic training.

Type

Research participants described two considerations in delivering training designed to meet the needs of surveillance staff. Training had to be maintained continuously whether the system was in the initial stage, expanding, or consolidating the system, and performed in a comprehensive way. These two considerations will be discussed in the following section.

Continuous training. A system cannot survive without continuous training especially considering high staff turnover (Int1). This turnover was commonly seen in the Armed Forces where personnel were constantly relocated around the country and at the MOH where employees were constantly seeking opportunities to be assigned to sites closer to large cities (Int 1, Int 9, Int 16, Int 23).

Research participants agreed that training should not only be offered on an on-going basis but also be conducted as frequently as possible (Int 16, Int 18). Research participants from the region with the most successful disease surveillance network stated that the epidemiology team provided monthly training for the surveillance staff at the district level that focused on various surveillance-related topics. They identified frequent on-going staff training as one of the most important contributing factors to their exceptionally good performance in disease surveillance (Int 23).

Comprehensive training. A research participant believed that the format and content of the training course was essential to the success of several systems with which

he had worked (Int 7). His recommendation for the initial phase of the evolution of the system was to have training courses no longer than two days duration. Longer courses appeared to overwhelm health care workers and made it difficult for them to retain the concepts needed to start reporting (Int 7). The objective of this methodology was to give the end users information that could be immediately used when they returned to their sites (Int 7). According to research participants, surveillance staff should start this new task immediately after they receive training (Int 18, Int 7). A participant shared his experience with one system that was not ready to be used though training was received. He explained that end users had lost their motivation by the time the system was ready to be used, so their performance was quite low. Reporting staff was overwhelmed by their other multiple tasks (Int 8).

According to research participants, the content addressed in training should, at minimum, include the following: a) the purpose and importance of disease surveillance, b) the role of health care workers in surveillance, c) the data collection and disease reporting process, d) data analysis and interpretation, and e) the detection of and appropriate response(s) to disease outbreaks or events (Int 1, Int 7, Int 8). Each of these content areas will be further explained in the following section.

Training should include content on concepts related to surveillance and functions that disease surveillance systems serve, the legislation that mandates and guides surveillance, and information about the most prevalent and relevant diseases in their community, region, country, and internationally. Trainers should explain how the disease surveillance information collected will be used for making public health decisions in public health (Int 7).

Surveillance staff should be taught who and how to notify supervisors about disease events of concern and which events required notification. The reporting process had to be clearly explained, with time assigned to allow trainees to practice using the data collection tool and reporting system (Int 7). A research participant recommended that examples of situations (e.g. how to report a patient being seen by a health care provider for the second time with the same complaint) experienced by the surveillance staff should be documented and shared with others (Int 18). Clearly defined terms were essential; especially what constituted a reportable and notifiable disease event. Participants commented that some staff would notify the team about events not required to be reported. Participants also recommended that definitions should also be shared with the physicians who made the diagnosis of such events. When physicians did not consider such definitions when writing the diagnosis, it was difficult for the surveillance staff to find complete information to report the event (Int 14).

It was recommended that training provide surveillance staff with skills to understand and interpret the data. Post-training evaluations revealed that surveillance staff, especially those located at sites outside the capital, did not know the basic concepts of epidemiology, disease surveillance, and outbreak detection and response. Therefore, they were not prepared to respond adequately to the information collected (Int 11). National surveillance teams and surveillance staff at the site specifically emphasized the need for training in epidemiology measurements and basic statistics for better interpretation of the data collected.

Surveillance staff needed training that enabled them to identify disease outbreaks and other events and appropriately respond to them. Research participants requested

training on diagnosing and treating the health events commonly presenting at their sites (Int 18). Furthermore, they needed explanations about strategies to detect and respond to outbreaks. Having this information empowered staff and reinforced the importance of their disease surveillance task (Int 16). Research participants shared their regrets about using a training approach that focused solely on the process of reporting (Int 11).

Train the trainers approach

Research participants recommended a simple and replicable training approach that enabled those who had been trained to train personnel at their sites (Int 18). Trainees then became trainers, thus contributing to a more rapid spread of knowledge about electronic disease surveillance (Int 6). The provided examples of such an approach that included nurses replicating the training for military personnel before these personnel deployed to remote areas in the rainforest (Int 19). In one organization, personnel agreed that every person who was trained had to replicate the training for the rest of the team (Int 4). The creation of regional teams in charge of the training was a cost reduction measure since the national team would not have to be responsible of all training throughout the country (Int 10). A train-the-trainers strategy made training more frequently offered and more widely disseminated across the country (Int 8, Int 9).

Institutionalization of training

Research participants mentioned that a system-wide training allowed them to develop an annual plan for training in epidemiology and disease surveillance for their organization for the first time. They began to incorporate this training into the curriculum of military nurses before they graduated (Int 2) and updated courses military health personnel received. This training was mandatory and part of the surveillance personnel

training curriculum (Int 21). The regional epidemiology team developed a certificate of epidemiology, which was a six-month online training program for surveillance staff at the regional and local level. This training represented a unique opportunity for certificate holders to pursue a graduate degree in an area of their expertise (Int 23).

In summary, training was greatly identified as a need for the successful implementation of these systems and as a way to address challenges such as staff turnover, workload and limited skills in surveillance. These challenges were commonly described across stakeholders' groups interviewed. The training strategy in place should be continuous and comprehensive, with a use of the train-the-trainers approach to increase the coverage of the population trained. Finally, in order to be sustainable, this training has to be part of the curricula offered by the institution or organization.

The skills acquired through training were a requisite for the reporting staff to fulfill the surveillance task. However, training also showed to increase the motivation of these health care workers. Motivation was important to incentivize these workers as they were assigned to one more task when they were already overworked and received low wages. The following section will explore the different strategies put in place to increase motivation of the reporting staff.

Surveillance Staff Motivation

Research participants contended that any surveillance system needed motivated and committed surveillance personnel in order to be successful (Int 8, Int 9). This contention was reflected in the following comment by a participant:

> *"Todo sistema debe empezar con el compromiso del personal reportante, si no hay eso, aun cuando el sistema fuera perfecto, no funciona". (Int 8)*

[English Translation:] "Every system should start with the commitment of the reporting staff; if that is not present, even when the system is perfect, it won't work". (Int 8)

They observed that low performing sites lacked motivated staff, especially in sites outside of the capital (Int 13). Life outside the capital is slower and people in general have less drive to perform well in comparison with the capital city. On the other hand, they saw that highly motivated, committed personnel more effectively performed their disease surveillance tasks (Int 15). Research participants mentioned people at the organizations where they worked who were already motivated to do a good job as part of their personal work ethic. One of the strategies implementers used was to identify these individuals and assign them surveillance duties. However, this was not always the case with all the surveillance sites across the country (Int 14, Int 17, Int 22).

As previously mentioned, research participants' observed that awareness of the health care workers about the importance of epidemiology and disease surveillance in the country was quite low, even at the MOH (Int 17, Int 18, Int 22). They emphasized the importance of heightening awareness within the entire organization when implementing a disease surveillance system, and suggested beginning at the surveillance staff level.

Surveillance Awareness

Enabling staff to increase their awareness of the purpose and importance of surveillance and specifically the significance of surveillance staff roles and tasks (Int 10, Int 14, Int 21, Int 22, Int 23, Int 8) was an outstanding need. The surveillance staff needed to be educated about disease surveillance in order to understand the importance of their surveillance tasks and the critical role they and the data they collected ultimately played in disease prevention (Int 13, Int 14). For instance, surveillance staff had to

register cases and collect flu samples as strategies critical to the annual WHO vaccine development process (Int 10). Research participants noted that once surveillance staff understood the consequences of submitting low quality or missing data or not forwarding it in a timely manner (Int 11, Int 14, Int 15), staff performance improved (Int 16).

Research participants recommended that implementers of disease surveillance systems work to change the views of those surveillance staff, particularly those who saw their task as merely routine or inconsequential (Int 16, Int 21, Int 22). They suggested reiterating messages about the important role that surveillance staff played in detecting and averting disease events with epidemic potential (Int 19). Feedback through the publication and dissemination of surveillance bulletins reinforced this message (Int 21). Staff was also very motivated when they were able to detect outbreaks at an early stage and prevent a more damaging situation (Int 17, Int 19). They found it motivating to apply their knowledge as in the creation of graphs using case data to assess disease levels for their target population (Int 2). One participant observed the difference between staff:

> *Hay algunos que reportan por obligación, y no hacienda la estadística adecuada, solo por cumplir, estos no están concientizados. Pero hay otros que trabajan con 600 personas en submarinos, y viendo los cuadros como van, los picos, y manejar la situación. (Int 16)*
>
> *[English Translation:] There are some who report only because they feel they need to; they do not analyze their information, only to comply with this task, those are not aware of the importance (of the system). But there are others that work with 600 people in a submarine and they look at what their charts show, the peaks that can present to manage this situation. (Int 16)*

While awareness of surveillance staff was critical for engagement on the reporting tasks, implementers soon realized that all health care workers had to be educated about the system, the importance of surveillance, and their role in the documentation of disease (Int 14). All health care professionals needed to be trained in surveillance-related data collection. Physicians at disease surveillance sites, for instance, needed to know how to accurately record the symptomatology and diagnosis of the patients they interviewed and treated (Int 22).

One strategy used to inform all professionals about disease surveillance was to regularly address findings in meetings with leaders. Research participants mentioned that the head of one surveillance site held monthly meetings involving all department chiefs to update them on the diseases they surveyed and inform them about current epidemiological data of concern (referred to as "epidemiological alerts"). High level authorities also used their media departments to disseminate information by e-mail or other means to all personnel in the organization about the current epidemiological status of the disease(s) they surveyed (Int 22). Research participants observed that when information about a reportable disease was highly disseminated, physicians were more likely to report required information about the disease (Int 22), thus facilitating the surveillance task for everyone.

Research participants explained that military organizations were hesitant to report disease outbreaks because personnel thought they would be punished or blamed for the incident (Int 11, Int 16, Int 18). Moreover, military personnel who were usually non-health care professionals did not understand the importance of reportable diseases (Int 16). Surveillance staff mentioned that they experienced a lack of interest and support

from their direct supervisors as evidenced by their request that they deprioritize data reporting in deference to engaging in other tasks or assignments unrelated to surveillance (Int 16). At many sites, commanders and others perceived disease surveillance as a last priority (Int 16).

Research participants recognized the need for increasing the awareness of non-health military personnel about the importance of disease surveillance systems and the contributions such systems can make to their mission, the lives of their soldiers, and the citizens and country they serve. These personnel should be educated using simple language (Int 14, Int 15, Int 16). Their understanding of the critical nature of disease-related reporting may facilitate the reporting process within their own sites (Int 14). Participants suggested applying the data already collected at their sites to illustrate the value of the information they collected. One participant proposed, as an example, that presenting the incidence of respiratory infections while ships were in dock compared to the increased incidence of such infections after the ships got underway, would be of great value to explain the increased risk of transmission of respiratory infections to their commanders (Int 14).

The importance of disease surveillance accorded by administrators of an organization reinforced the importance perceived by staff at the organization (Int 17). Research participants observed that when the highest ranked person at the site knew about the system and the need to comply with it, the chance that the task would be accomplished by the organization was heightened (Int 17, Int 18, Int 21). A participant noted that having an Armed Forces commander who was aware of the importance of disease surveillance systems led that individual to support the surveillance staff in the

tasks they needed to accomplish (Int 16). In contrast, the participant recalled a circumstance where an uninformed Armed Forces base commander called in surveillance staff to castigate them for reporting a disease outbreak. Once the medical director explained their actions and the surveillance system to the commander, the outcome was positive in that measures were instituted to prevent similar misunderstandings in the future (Int 16).

Research participants stated that the dissemination of information about the existence and products of a disease surveillance system was a key component to create this awareness of the importance of the system (Int 14). However, the dissemination process could also be quite challenging (Int 15, Int 16). A lack of information dissemination about the surveillance system invariably resulted in an organization-wide lack of awareness about surveillance. Participants commented that when they supervised sites, they could see evidence that the head of the site did not view the system as important and that the commander and personnel were uninvolved in surveillance. Non-health care military personnel did not regard surveillance as part of their responsibility, viewing it instead as the sole responsibility of health care workers (Int 2). In order to remedy a situation where personnel in general lacked awareness about the existence and purpose of their organization-based disease surveillance system, research participants strongly recommended disseminating information about the system through regular channels (Int 17). They observed that the process of dissemination took time because of existing bureaucratic barriers to sending formal documentation to every reporting unit (Int 15, Int 16). However, the strategy of broad dissemination of information to the entire organization was important. It not only informed personnel about a system integral to the

organization, but also gave the commander the opportunity to become involved, share her or his perspectives, and ultimately support surveillance personnel in the tasks they had to perform (Int 15).

Surveillance Site Resources

Motivated staff typically had the resources required to complete their surveillance tasks such as access to a computer, a telephone, or a community-based Internet café (Int 14, Int 19, Int 9). Participants found that providing these resources such as the purchase of computers for their work group was quite motivating (Int 8).

> *Particularmente yo no espero que me den algún reconocimiento simplemente lo tomo como una parte importante de mi trabajo y como un granito de arena, el sistema finalmente como dijo el doctor, somos 128 reportantes, entonces yo soy uno de los 128 pero generalmente no esperamos ningún reconocimiento o algo, quizá de repente un poco de apoyo en lo que se refiera a tecnología , por ejemplo en este caso, como te decía, a veces los comandos no quieren dar dos soles, o sea, dos soles que no es nada pero inclusive esos dos soles no les daban entonces el enfermero decía, 'Si no yo tengo que sacar de mi dinero para reportar', entonces tampoco no era justo. (Int 14)*
>
> *[English Translation:] Personally, I do not expect any recognition. I simply take it as an important part of my work, as my small contribution. The system is finally, like the doctor said, we are 128 reporting staff, then I am only one of those 128 so we do not expect any recognition. Maybe just support with access to the technology. For example, I was telling you about that time when the commander did not want to give the nurse two soles to do the reporting (to use the*

Internet café). It is not fair then the nurse has to spend his own money to do this (Int 14).

During the planning phase, participants described how important it was to consider the resources required to implement a system. The economic resources, human resources and the infrastructure already in place had to be assessed in order to determine needs at the central, regional and district levels (Int 1, Int 21). The resource planning should be based on the system and technology being implemented, including laying out all the processes such as the data collection, data reporting and analysis of the data undertaken through the evolution of the system, including the initial, expansion, and consolidation phases (Int 15).

Research participants emphasized the importance of considering the resources available when deciding to expand the system (Int 1). One problem to avoid was the funding of recurring payments because if the payment failed, then the system failed. For instance, several surveillance sites paid for Internet accessibility. However, administrative problems could slow this payment and interrupt the service, thus bringing surveillance reporting to a halt (Int 8, Int 9).

Availability

Resources were one of the biggest challenges that the implementation of surveillance systems faced. Research participants expressed great concern regarding the resources that their organizations or institutions had in place, the resources that were committed to surveillance, and the external funding available. Participants identified three issues: limited human resources, lack of appropriate equipment, and lack of access to technology and the Internet as the most common barriers to implementation.

Lack of access to Internet connectivity was one of the main concerns among research participants. There was controversy among implementers on developing online vs. standalone systems because many sites did not have access to the Internet. Several sites were not incorporated into the main surveillance system as they did not use computers and using the phone for reporting would only cause a work overload for them (Int 6).

The main reasons cited for not having Internet access were a "lack of funding" and a "lack of availability of such services in their geographic area." (Int 8, Int 13, Int 14, Int 15, Int 18, Int 19, Int 4, Int 6). For military organizations, some units had to go on missions for several weeks to areas with no access to computers or phones (Int 4, Int 14). In other cases, participants mentioned that surveillance staff had to use Internet cafes or their own personal computers or telephones to make the report (Int 10, Int 15, Int 17, Int 21). Internet accessibility was also a challenge for training sessions (Int 6). Unfortunately, even when some sites had Internet access, personnel in surveillance offices did not share that access (Int 14). Internet access in certain areas of the country was often very slow, making the reporting task even harder (Int 16).

Participants noted that a lack of adequate equipment was also a frequent problem (Int 23, Int 9). Commonly, there were only a few computers at the site causing surveillance staff to wait for an available computer in order to input or report their data (Int 16). Computer break down (Int 16) and public pay phones that were out of commission exemplified additional equipment problems (Int 18, Int 19). At the regional level, the epidemiology office did not manage data with their own server, thus having to use the regional government network which was very slow since it served many work

areas (Int 23). Additionally, research participants commented about the inaccessibility of software resources needed to use the analytical tools they needed (Int 8).

Research participants commented that resources could not be neglected at the surveillance supervisors' team level as well. Supervisors needed an adequate work environment and access to tools to monitor the system and provide support to the surveillance staff. A fully equipped office with computers, Internet access, and telephone lines to communicate with the surveillance staff were essential in the process of disease surveillance (Int 21).

Administrative support

Beyond the lack of resources, research participants also observed that their commanders did not prioritize the surveillance tasks even when they were mandatory. Even when equipment was purchased, it was assigned to the highest ranked personnel instead of the surveillance staff at the site (Int 14). Many times, direct supervisors at the site would not allow the surveillance staff access to computers or phones already in place (Int 14, Int 15, Int 16, Int 4). Furthermore, surveillance staff would be asked to do other tasks like administrative activities instead of prioritizing their surveillance role (Int 16). Research participants mentioned that they often would not receive logistics support to do surveillance, such as the cost for using an Internet café when they needed to send a report or even the permission required to leave the base to access the Internet (Int 16, Int 19).

Performance-based access

Resources had to be present at every level. An initial strategy was to make sure the users would have the resources to be able to use the electronic tool developed (Int 1, Int 8). As one participant commented;

Si vas a introducir una herramienta que utiliza tecnologías web, las personas, al menos debe de haber una computadora para que las personas lo hagan, algo tan simple como eso. (Int 1)

If you are going to introduce a tool that uses web-based technologies, the people, at least need to have a computer so they can use the tool, something as simple as that. (Int 1)

In the case of the system used by the Armed Forces, information could be sent by calling a toll free number, thus requiring access to a landline or cellular telephone (Int 1). Research participants emphasized that surveillance sites with access to technology used by the system had few problems with reporting (Int 14). Furthermore, having a usable Internet connection, especially one that was not slow, helped with their surveillance tasks (Int 9). Having a computer with Internet access also meant surveillance staff could view their reporting data, analyze the information, and understand the status of the diseases surveyed within their population (Int 19, Int 23, Int 3).

Existing resources use

In a resource limited setting, implementers should rely as much as possible on the resources in place as this would help the sustainability of the system (Int 21). Implementers considered Internet access when selecting the sites for implementing the sentinel surveillance system (Int 8, Int 15). At the same time, they paid attention to country context, which sometimes provided favorable opportunities for the implementation process. A recently adopted approach by the MOH to allocate budgets according to surveillance performance results enabled implementers to request funding to strengthen the MOH surveillance system (Int 10). With this money, they requested the

purchase of equipment, information systems, human resources, and the logistics required (Int 10).

In the same way, surveillance administrators creatively solved resource challenges. They hired temporary workers to start monitoring the system. Personnel at sites without Internet and telephone were trained to communicate surveillance data by radio to sites that had a means of reporting the information (Int 8). When no budget existed to buy computers, implementers lobbied at the regional surveillance level for support that would allow the use of regional resources for surveillance tasks (Int 10). Research participants mentioned that it was essential to create awareness about the importance of surveillance at all organizational levels. This awareness not only allowed for assistance with resources but also facilitated the processes associated with surveillance, such as a Director's willingness to sign a document in order to have a sample leave the site (Int 22).

Incentives

Implementers observed a positive impact of non-financial incentives on the morale of the surveillance staff. For instance, a national "Epidemiology Day" was designated to increase awareness of disease surveillance and to honor those who demonstrated excellent performance. Administrators at the national surveillance level created a ranking to identify the best performing units during the training courses (Int 18). Surveillance supervisors used this ranking to congratulate their staff through a formal document and during a once a year ceremony in association with "Epidemiology Day" that was held at the organization (Int 21, Int 3, Int 4, Int 15, Int 19). Research participants believed that such performance site comparisons contributed to staff

motivation (Int 23). As an additional incentive, personnel from the best performing sites across the country were invited to participate in the "Epidemiology Day" celebration and had their travel funded (Int 4). National level administrators prepared training diplomas for that day that were given to recipients by the highest authority in their organizations (Int 23).

As mentioned earlier, training was perceived as an incentive for surveillance staff, especially for those who worked in sites outside the capital city (Int 4, Int 9, Int 18). Research participants indicated that personnel highly valued the training courses that funded their travel expenses to attend the course (Int 8). They also held training courses that offered medical education credits which also proved to be an incentive for attendees (Int 2).

Training as a motivator

Besides the benefits already mentioned, training was perceived as a motivator (Int 9). Surveillance staff who participated in training gained more tools with which they could improve their performance and the knowledge to educate all personnel on the importance of disease surveillance (Int 16). The use of an electronic disease surveillance system enabled surveillance staff to have knowledge about the overall health situation at their sites as well as the region and country, which they also considered a motivating experience (Int 17).

Finally, as a consequence of the training process research participants also identified areas where system improvements were needed. They identified the need for public health training to be strengthened following undergraduate school for all health care workers (Int 10, Int 15). They discovered, for example, that more training in health

informatics should be developed and offered since, at the time of this study, only one school in the country offered a certificate and a master's degree in health informatics (Int 20). They also advocated that training opportunities in epidemiology offered by the MOH be opened to health care workers from all institutions including the Armed Forces (Int 4).

Accountability

In the case of delays in surveillance report submissions, most military organizations addressed accountability by means of written formal documentation of the incident. Documentation was usually followed by sanctioning the individual(s) responsible. A sanction might mean the individual's supervisor(s) personally addressed the issue with them or their supervisors wrote an unsatisfactory performance note on their resumes. Military-affiliated research participants recommended a more flexible approach to such problems. They suggested direct contact with surveillance staff be made as an initial effort to assess the reason for the delay and, if reasonable, to provide a deadline extension. In the case of a continued delay, research participants recommended immediate notification of the superior of the surveillance staff. Additional delays would result in informing the health department chief and finally the unit commander (Int 15). Participants shared that the current military process of documenting and sanctioning hurt their morale. It resulted in site surveillance staff compliance with reporting deadlines, but only for the purpose of avoiding being sanctioned (Int 14, Int 16).

In summary, in order to generate timely and quality data, the reporting staff needed to be skilled and motivated; have access to adequate resources to collect and transmit the data collected and be assigned to a feasible task. This feasibility comprised

having simple, flexible and standardized procedures in place, including the surveillance tool used by the system.

Next, the researcher will describe the role and functions of the national and regional team to provide the reporting staff with the skills, resources and support required to fulfill the surveillance task, as well as to ensure the maintenance of the high performance and quality of the data generated by the system.

At the national and regional team

The third and final level of the model is the national and regional disease surveillance team level. A national team is created to oversee the implementation process of a disease surveillance system. In order to provide closer support to the surveillance sites in a timelier manner, the national team often relied, when available, on regional teams for this purpose.

For this level, the researcher will describe the characteristics of these teams and the functions performed to ensure the surveillance staff at the local sites generated the quality and timely data required. The outline of the national and regional team level is shown in Table 5.

Table 5: Outline of the national and regional team level concepts in the Peruvian electronic disease surveillance system implementation model, as identified by the primary data analysis.

Team characteristics	• Knowledge and skill • Availability • Continuing education
Team role	• Monitoring • Feedback • Supervision

Team Characteristics

Research participants contended that the essential activities of training, monitoring, supervision and feedback could be accomplished only if the national surveillance team was skilled, highly committed (Int 17, Int 18, Int 21, Int 15, Int 3, Int 8) and available. Participants emphasized the importance of creating a team to lead the implementation process. This group of people had to be interested, actively involved in surveillance, convinced of its usefulness (Int 21), and experienced in surveillance itself or experienced working in the organization in which the system would be implemented (Int 13, Int 7, Int 21, Int 22, Int 23).

Knowledge and Skill

Research participants noted that successful disease surveillance implementation teams maintained a high level of technical skills and high morale (Int 23), which was appreciated by the surveillance staff at different reporting sites (Int 17, Int 18, Int 21, Int 15, Int 3). When recruiting personnel, implementers selected people motivated to work in the area of surveillance (Int 23, Int 15). Inside this team, at least one person had to have a clear vision of where the system should go and would be able to effectively interact across various levels in hierarchical organizations (Int1). The national team would be the link between all of the surveillance sites and the highest level authority in the organization or institution (Int 1).

The skills and experience of the national surveillance team influenced the process of implementation (Int 1, Int 9). The same surveillance system, for example, was implemented in the Peruvian Navy, Army and Air Force at different times but in the

order indicated. Research participants observed that the implementation process was faster and easier once the team had gained more experience and had structured the training. They mentioned as an example of how the implementation and expansion of the system in the Peruvian Air Force was completed in less than six months compared to much longer times for implementation and expansion in the other two branches. The Air Force had fewer units, but the Army, which had many more units than the Navy, consolidated their system in one year compared to the three years it required for the Navy to achieve consolidation. Participants believed that the experience of the national implementing team with the surveillance system and the implementation process contributed to a more efficient and effective implementation within each subsequent Force (Int 1). One participant shared the following view about the need for implementers to have epidemiological knowledge when working on initiating a disease surveillance system:

> *El equipo que va a implementar debe estar comprometido y capacitado, porque eso es lo que nos hemos podido dar cuenta; quizás el sistema funcionó porque nosotros veníamos de la parte operativa de hacer epidemiología y cuando nosotros empezamos a implementar, podíamos responder preguntas. Qué pasaba si nosotros no sabíamos nada de epidemiología y llegaba acá y me decían sabes qué, implementa un sistema, estaba en la mera calle, no sabía. (Int 11)*
>
> *[English Translation:] The team that is going to implement [the system] has to be committed and skilled, because what we have realized, maybe is that the system worked because we came from the operational side of epidemiology, and when we implemented the system, we could respond to the questions. What would have*

happened if we did not know about epidemiology and we came here and were assigned to implement a system, where we did not know how to do it. (Int 11)

Surveillance staff valued the high-level surveillance skills and knowledgeable use of the surveillance instrument that characterized the national surveillance team (Int 1). If an electronic tool was used, technological expertise was needed to maintain the tool in terms of adding or changing functions. In addition, a disease surveillance system required effective user support and training. Engineers assigned to the national surveillance team had expertise in the specific software program used to develop the tool. If the tool had been developed by another organization, the engineers would have needed access to the programming code used to build the tool (Int 12, Int 8, Int 15).

It was important that at the national level the disease surveillance team had an annual work plan for the activities they needed or intended to perform during the course of the year (Int 4). Research participants therefore recommended having a national team that was exclusively dedicated to surveillance (Int 21, Int 15, Int 23). The reality, however, was that the team had other assigned tasks unrelated to surveillance, leaving team members little time to develop new features or processes that would improve the surveillance system (Int 8). Research participants shared that motivation was high among the team. For instance, people would work extra hours because they knew the job was important, particularly when a need arose to respond to disease outbreaks (Int 23). Participants also commented that when there was political will, personnel were assigned to the surveillance system but the assignment was temporary and based on the priorities of the person in the highest administrative office (Int 21).

Availability

Research participants commented that the perception of teams available to surveillance staff was quite important (Int 15, Int 18). Disease surveillance systems that functioned effectively were characterized by constant communication and the presence of a surveillance team that surveillance staff knew that they could call when problems arose (Int 12, Int 15, Int 18). Team availability and responsiveness to the concerns of staff at any level contributed to the development of trusting relationships (Int 7) that ultimately facilitated a more effective surveillance system.

Continuing Education

Research participants stated that if the national implementation team was committed to the surveillance implementation project and had previous experience and training in disease surveillance, they were able to better support surveillance staff and respond effectively to any situation that might have arisen (Int 11, Int 17). Therefore, as the implementation process evolved, it was important to maintain an advanced level of training for surveillance supervisors as well. Supervisors complained about not having the analytical skills to analyze the data they had been monitoring for years (Int 6). However, addressing this issue was especially challenging. The cost of continuing surveillance education, the long hours of work experienced by supervisors, and the small salary of supervisors as government employees (Int 15) served as barriers to meeting the continuing education needs of these key individuals.

Team Role

The team's functions include monitoring, feedback, supervision and support.

Monitoring

While training was key to providing the skills required and motivate the surveillance staff, system monitoring was a core activity in the maintenance of an effective electronic disease surveillance system (Int 10, Int 21, Int 9). The words of one research participant were echoed by several who contended that system success depended on close monitoring of the system (Int 1, Int 7, Int 8):

> *Tercer pilar, creo que es la monitorización y el seguimiento, un sistema, la implementación de un sistema de vigilancia, creo, no puede ser exitoso si es que no existe un monitoreo adecuado del sistema. (Int. 1)*
>
> *[English Translation:] Third pillar, I think is the monitoring and follow-up, of a system; the implementation of a disease surveillance system cannot be successful if there is no adequate monitoring of the system. (Int 1)*

Research participants advised having at least one trained person assigned to monitor the system, including assessing data quality and ensuring reporting accuracy and timeliness (Int 1, Int 15, Int 4, Int 6, Int 8). Participants specifically mentioned that a well-functioning system depended, in part, on monitoring all aspects of reporting disease surveillance data (Int 13). The designated system monitor was responsible for communicating with surveillance sites, clarifying issues and addressing questions from staff at the site, and engaging in supervisory visits (Int 8). On the other hand, one of the factors consistently observed in a failed surveillance system was a lack of adequate system monitoring which was sometimes related to assigning monitoring responsibility to an untrained or inadequately trained staff member (Int 1).

National surveillance team members held the primary responsibility for system monitoring. Continuous monitoring was difficult to maintain when these personnel

became overloaded with other task assignments (Int 2, Int 10, Int 8). Research participants observed that when no one monitored the system and contacted surveillance staff when data reporting was overdue or missing, the proportion of units reporting disease surveillance data by a given deadline date dropped from 80% to 50% or 60% of the units (Int 11).

Monitoring was important to identify surveillance areas or functions that were not working effectively. This was accomplished through the measurement of indicators (Int 22). When indicator data were not forthcoming, training (Int 15) and supervision visits were conducted in an effort to respond to what had been identified as a problem (Int 10, Int 21). The evaluation of the system was important in an effort to ultimately assess the effect of the health promotion, and disease prevention measures that had been implemented (Int 6, Int 18).

Feedback

Feedback was one more function of the national surveillance team that was deemed essential for this process. Research participants agreed that feedback was essential in both directions. From the end users, it was important to collect suggestions or requests to improve the tool and the surveillance processes (Int. 1, Int 10, Int 12). The national surveillance team had channels established that the end users utilized to communicate the problems they had with the system or the tool or any suggestions for change (Int 12). On the other end, surveillance staff received feedback on the information they collected and sent. Study participants agreed that the creation of bulletins and reports was very useful (Int 9, Int 13, Int 18, Int 21). Reports were sent to every region in the country (Int 15), weekly (Int 4, Int 15, Int 18) monthly, and annually (Int 3). These reports were sent both by email and by written format (Int 18). Even when it took a long

time for the written reports to reach the recipients, surveillance staff at the surveillance sites valued having a print document to show their supervisors and coworkers the work they were doing (Int 18, Int 3, Int 4). The surveillance staff deemed it essential to see the information collected in a way that was useful to them; research study participants believed that data usefulness was helpful in motivating surveillance site personnel (Int 2, Int 3, Int 14). The report had great credibility as it came directly from the organizations (Int 14).

Research participants also recommended providing end users feedback on their performance. For instance, one organization created a ranking of the sites according to their overall performance and timely reporting. During the national "Epidemiology Day' they congratulated the sites that performed most effectively (Int 21, Int 3). An additional strategy they used was to have monthly meetings to share information and congratulate staff for their accomplishments (Int 23).

> *La evidencia de que el sistema permite identificar problemas, la evidencia de que la información siendo usada adecuadamente, genera una serie de acciones que permiten además construir o generar información útil; los boletines con los reportes de la situación por cada unidad militar ayudó mucho y lo otro era, sacar un ranking de cumplimiento y oportunidad en la notificación para que el personal se sienta motivado. (Int 21)*
>
> *[English Translation:] The evidence that the system allows the identification of problems, the evidence that information is adequately being used, generates a series of actions that also allows generation of useful information. The bulletins with the information of the health situation of every military unit helped very*

much, the other thing, was to have a ranking with the reporting performance which made the personnel feel motivated. (Int 21)

Supervision

Research participants stated that supervision visits should accompany monitoring and evaluation activities whenever possible (Int 10). Supervision visits depended on the budget and the resources available. External funding supported these activities in military organizations (Int 11, Int 15, Int 9). The team planned to supervise units based on the needs of the system (Int 10), while also considering their geographic accessibility to the units (Int 15).

Implementers realized that when they supervised a unit, the reporting increased and the act of supervision motivated the surveillance staff in several ways (Int 10). The simple fact of visiting the surveillance staff in their sites helped to build a relationship with them (Int 9). Listening and learning about their local problems, their difficulties and challenges were also considered an important part of these visits (Int 10). The supervisory team provided information of what was expected from the sites before supervising them (Int 4, Int 11). There was a tool they developed for the supervision visits (Int 15). During the visit, the team compared the data reported, which appeared on the electronic system, with the one registered in the site records book (Int 11, Int 15, Int 2). If any problems were identified, the team retrained the surveillance staff to clarify any misunderstandings (Int 2, Int 9, Int 11, Int 15, Int 18). In addition, the team would meet with all the personnel at the site to let them know about the system and request their commitment to the task (Int 9).

This visit was also an opportunity for the team to learn about the site, the resources in place, the process in place, and the surveillance staff's morale. This

understanding was important to the team to determine what was feasible to ask from the surveillance staff and not to put in place unfair accountability measures (Int 11, Int 15). After the supervision, a report was prepared with the recommendations if they found any places for improvement (Int 15). The team was careful to emphasize the objective of the supervision as a way to improve on their tasks and the final report not to be seen as punishment to them (Int 5).

Support

Research participants believed that when the surveillance regional and national level maintained constant communication with the surveillance staff at the site level, a high motivation environment was kept at the site (Int 10, Int 13). They were motivated when they received support to fulfill their surveillance tasks from the national and regional surveillance team (Int 3). The supervision visits also motivated the personnel by facilitating the contact, the sharing, and the building of a relationship between the national and regional surveillance team and the surveillance staff at the sites (Int 9).

In summary, the national and regional teams should be composed of highly motivated and skilled personnel. The critical functions of training, monitoring, supervision and feedback address the critical points of providing the skills and increasing the motivation of the reporting staff to conduct the surveillance task, ensuring high performance at the surveillance sites. At the same time, the national team has the critical function of informing the institutional administrative level of the diseases and events under surveillance. By presenting the analysis of the data collected in a useful way to the high authorities of the organization or institution, they can translate this evidence into measures that would benefit and enhance the population under surveillance. In this final

section, the researcher will explain the criticality of this last piece to the sustainability of the system.

Institutional administrative level

Finally, this model comes back to the first level described in order to conclude the description of the model. The institutional administrative level is essential to act on the information that has been collected by the reporting staff; and analyzed and formatted by the national surveillance team to inform this level.

In this last segment, the research will describe the final critical concept that has to be present at the institutional administrative level to maintain a high performing system.

Value and Action

In an effort to implement a sustainable disease surveillance system, research participants indicated that high-level authorities needed to be able to value and use the information generated by the system by ultimately transforming findings into decisive actions that addressed disease trends, outbreaks, or other situations for which surveillance data were available. It was their actions in response to the information they had been provided that indicated to surveillance staff that the tasks they performed were valued and worthy of continuation.

Stakeholders at different levels of the surveillance system perceived that demonstrating the usefulness of an electronic disease surveillance system contributed to system success in several ways. The system provided the surveillance team with valued disease monitoring information, particularly in remote areas where the need for surveillance data was particularly pronounced. Disease surveillance enabled them to not only detect and respond quickly to outbreaks, but also to more effectively plan, budget

for, and manage on-going surveillance activities as well as outbreaks or other problems. It also enabled them to tailor health promotion and disease prevention interventions to populations and geographical areas in need, thus potentially affording improved disease morbidity and mortality.

Disease Detection and Rapid Response

Research participants appreciated having access to disease surveillance evidence in different geographical areas of Peru. Disease surveillance information that became available for the first time in some remote areas of the country (Int 3, Int 15, Int 17, Int 19) was particularly valued, given past experiences with disease outbreaks in such areas (Int 19).

The surveillance system enabled staff to document the occurrence of health events (Int 21), especially outbreaks, which permitted a prompt response to the event that had previously not been possible (Int 1, Int 6, Int 13, Int 16, Int 19, Int 10, Int 23). Armed Forces research participants provided an example of a foodborne disease outbreak they were able to detect and respond to in a population of new recruits who were initiating training (Int 16-ST-PN). Changes in kitchen and water management were made based on food-borne illness outbreak recommendations, (Int 16) as well as changes in food preparation and serving in their celebration events (Int 18). A research participant offered a response to the experience in the following comment.

> *De repente esa es la satisfacción, de poder parar de repente, la enfermedad, de poderla detener o de repente de tomar las medidas necesarias en ese momento, es el bienestar del paciente. La verdad que a mí me dio mucha satisfacción de repente, el hecho de tener mis cadetes ahí y sentarme a curarlos, qué sé yo. Esa es la satisfacción, de repente no esperar que siga avanzando. Esa es la*

satisfacción propia como personal de salud, al margen de repente que puede haber una felicitación, que sí la ha habido, reconozco. Sí, he tenido felicitación de parte de COSALE; pero al margen de todo eso, es la satisfacción personal que uno puede tener. (Int 17)

[English Translation:] Maybe that is the incentive, to be able to stop the disease, maybe prevent or take the adequate measures in that moment (to stop the progression of the disease), to be able to cure my soldiers. That is my incentive. To prevent the progression of these cases, this is my incentive as a health care worker, besides the recognition from the Army Public Health department that I have received. (Int 17)

Planning, Organizing, and Prevention

In addition to the improved detection of and heightened responsiveness to disease events, research participants appreciated the planning and organization that a disease surveillance system afforded. They highlighted the importance of having a system that produced data that decision-makers actually valued and used (Int 21, Int 23, Int 9, Int 20). Access to surveillance information enabled decision-makers to better prepare themselves by developing appropriate budgets and anticipating the need for and requesting medication (Int 18, Int 14, Int 16); programming for the mobilization of human resources (Int 3); and planning and providing disease prevention activities, particularly prior to the deployment of military personnel (Int 21). Finally, surveillance information could document the impact of their disease prevention and health promotion activities, some of which indicated a decreased incidence and prevalence of certain diseases within the populations they served (Int 19, Int 23, Int 22).

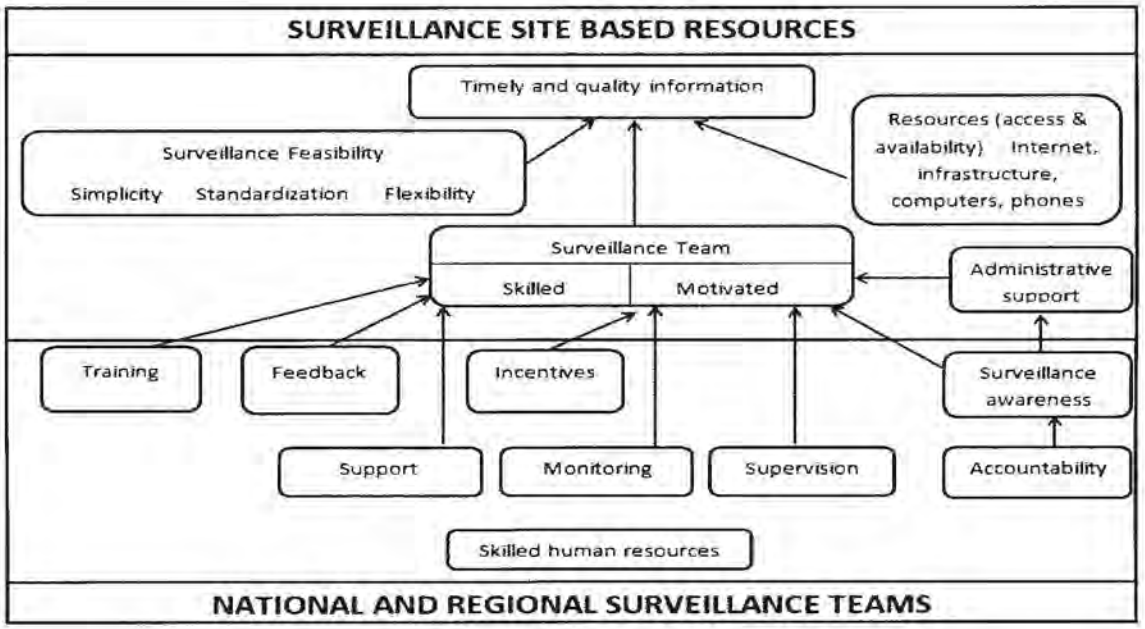

Figure 9: Surveillance site level, and national and regional surveillance teams' level.

The observation that the organization or institution responded to disease events that were reported served as an incentive for surveillance staff to continue with their work (Int 16). While many strategies helped the reporting staff at the sites to increase their commitment to the surveillance system, evidence of data use by system personnel underscored the importance of the system and showed the surveillance staff that despite the many challenges they faced, the disease surveillance system was worth maintaining. The concepts and relationships at the surveillance site level and the national and regional team level are summarized in Figure 9.

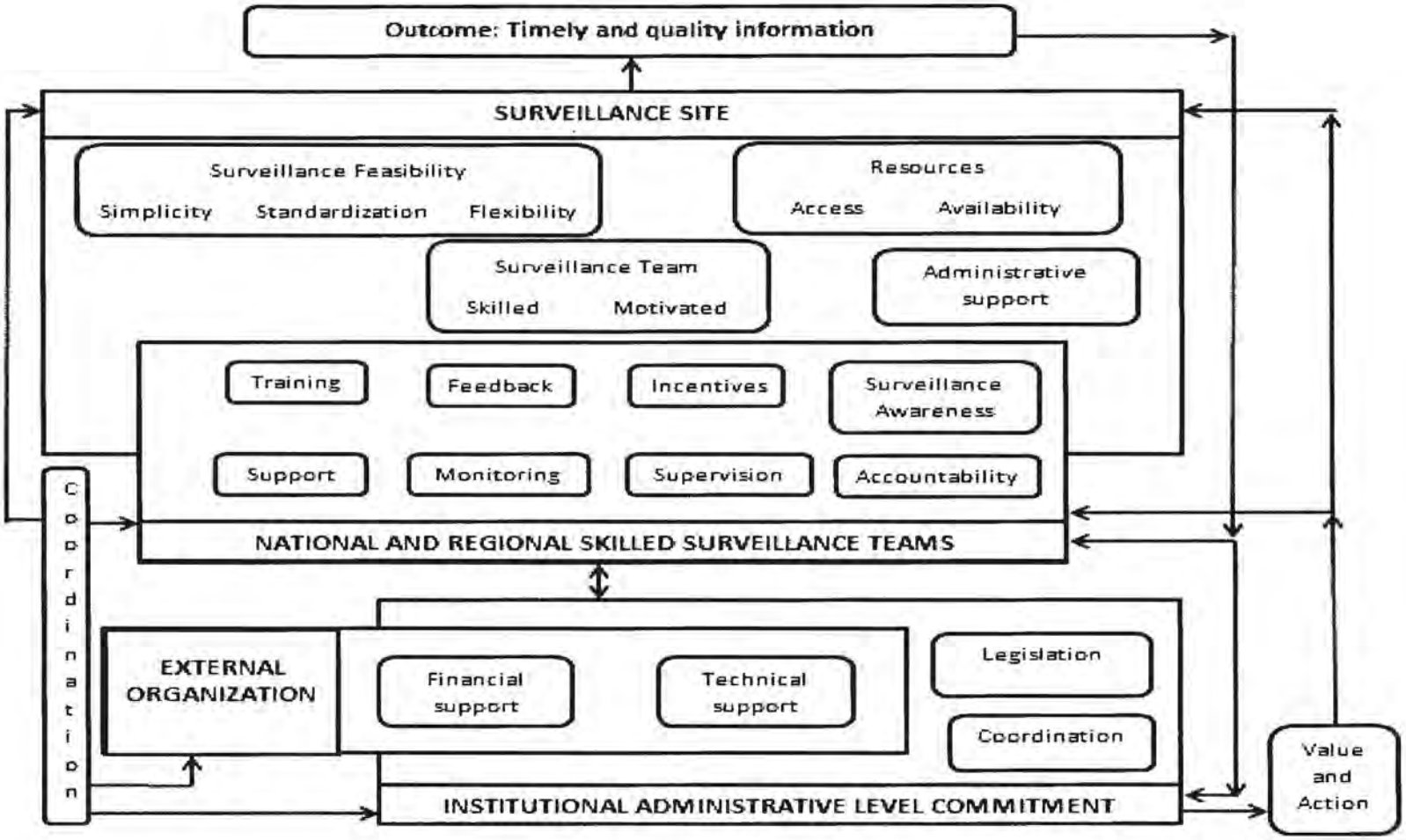

Figure 10: Peruvian Electronic Disease Surveillance System implementation model.

In summary, value has to be perceived at the institutional administrative level in order to put in place the measures to respond to health emergencies and to plan, organize and prevent the occurrence of diseases or events under surveillance. The public health actions implemented and their consequent impact on the population's health were considered the ultimate motivator for the health care workers performing the surveillance tasks at the surveillance site and at the national and regional team. The Grounded theory informed model developed by the researcher using the qualitative data collected in Peru is summarized in Figure 10 with the three levels identified.

CHAPTER 6: TRIANGULATION AND REVISED MODEL

After developing an electronic disease surveillance systems implementation model (EDSSIM) using primary data collected in Peru, the researcher incorporated triangulation from three sources to validate and refine the model. The steps, procedures and products of each data source explored in this study are summarized in Figure 11.

Comparing the concepts across data sources

The researcher compared the results of the electronic disease surveillance systems implementation model to those obtained using three methodologies: (1) the systematic review of the literature on health-related program implementation factors in developing countries, (2) the gray literature search for implementation factors of electronic disease surveillance systems in developing countries, and (3) the experts consensus report on implementation factors related to electronic disease surveillance systems in developing countries (Tables 6, 7 & 8).

The researcher identified three organizational levels associated with the implementation of the Peruvian EDSSIM. The researcher explored every level for concordances and discordances in the concepts and the findings of the different methodologies incorporated in this study.

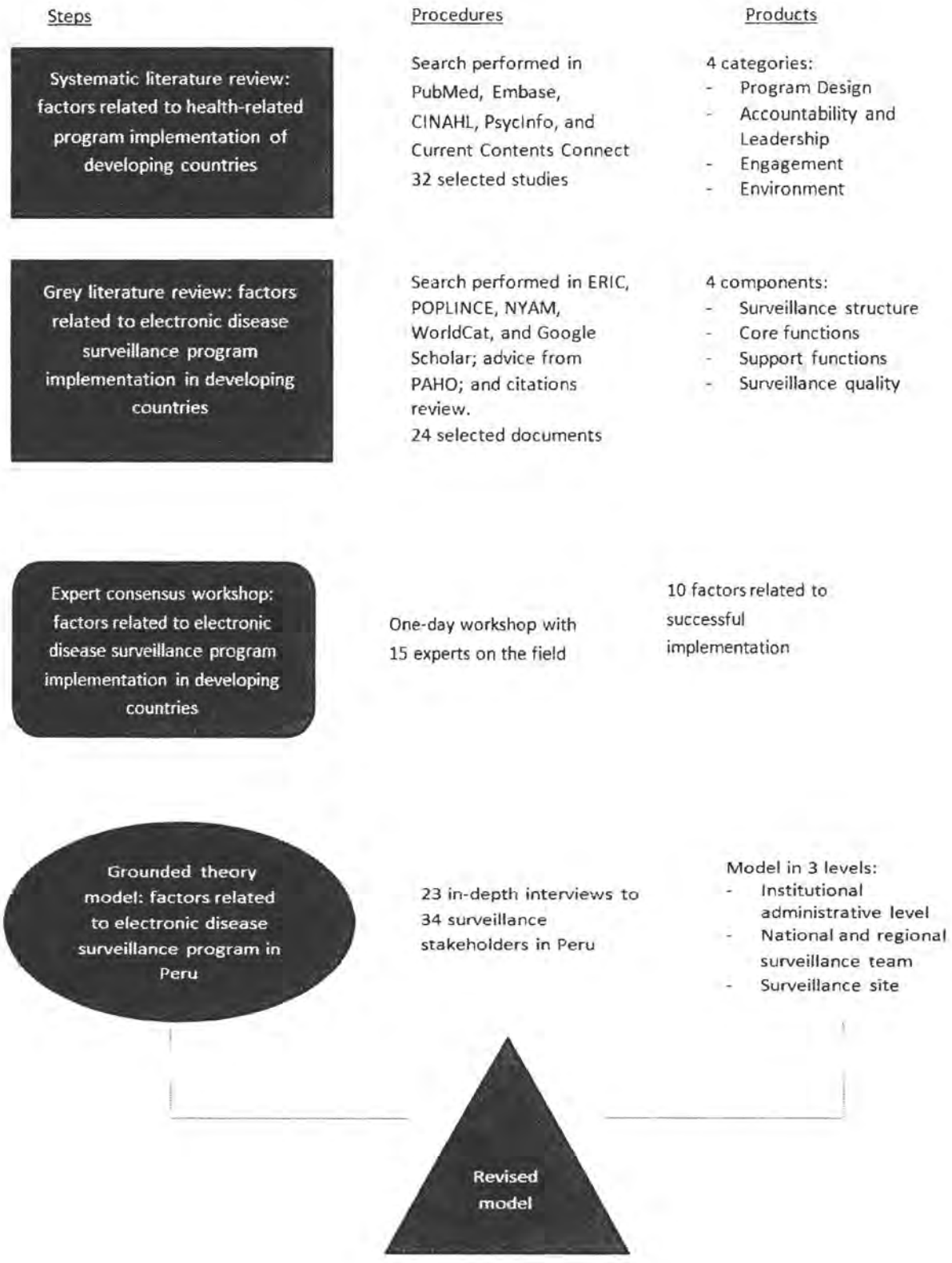

Figure 11: Steps, Procedures and Products of the study used to create a refined model.

At the administrative level of the model

Comparison to the systematic literature review

When comparing the results of the EDSSIM to those of the systematic literature review described in the background chapter, the researcher noted most of the factors described in the literature review were present or were part of concepts in the electronic disease surveillance systems implementation model. The concepts identified by the systematic literature review that were present in the model, included "engaging key stakeholder groups" (awareness of the significance), "accountability policies" (legislation), "program leadership" and "political environment" (commitment to ownership), "value and action" (capacity building), and "donor and external support" (financial commitment).

The systematic literature review presented the concept of "engaging key stakeholders groups" as the Peruvian EDSSIM model concept of "awareness of the significance" at the highest organizational level of the system. System implementers would engage the key stakeholder group as a consequence of educating high-level administrative personnel in the high administrative level in an organization about the importance of surveillance. The "accountability policies" subcategory included the government legal and regulatory aspects for the program that in the Peruvian EDSSIM was discussed as the "Legislative action" concept. The "program leadership" and "political environment" subcategories underscored the importance of active leadership at the government level and the value of committed national political leaders in support of a program. This subcategory contributed to build the "organizational commitment" concept in the Peruvian EDSSIM.

The "donor and external support" subcategory in the literature referred specifically to the "financial support" concept in the model. The term "donor support" to refer to the "financial support" concept may have been used by authors in the literature because most of the program implementation experiences in developing countries published in the literature related to systems whose funding was supported by external organizations. The "capacity building" subcategory was included in a broader Peruvian EDSSIM concept named "value and action." According to the Peruvian EDSSIM, if an organization recognized the value of the surveillance information collected, personnel at high administrative levels would use this information to build the capacity needed to support the system.

The systematic literature review did not contribute to any additional concepts at this level. Conversely, several concepts at the high administrative level of the model not identified in the systematic literature review were present in the Peruvian EDSSIM. These concepts included "organizational need," "technical assistance," and "coordination." Since, of necessity, the focus of the systematic literature review was health-related programs concepts such as "organizational need" might fail to be identified due to the differing focus and needs associated with these programs. In terms of "technical assistance", the capacity of each organization implementing a program might vary as would its consequent need for such assistance. The "coordination" required to implement a program would depend on the organizational levels and sectors involved. Electronic diseases surveillance programs were typically national programs for which coordination was essential.

Comparison to the gray literature review

At the administrative level, findings form the gray literature coincided with the electronic disease surveillance systems implementation model in several concepts. Although the names of some concepts differed between the model and the gray literature, they shared similar ideas. Commonalities between the concepts in both methodologies included "advocacy" (awareness of the significance), "political commitment" (commitment to ownership), legislation, financial commitment, "development of partnership and networks," and "communication" (coordination), "development of partnership and networks" (technical assistance), and "surveillance strategy" (value and action). The statements in quotations and parentheses relate to the gray literature and the Peruvian EDSSIM respectively.

"Advocacy" was presented in the gray literature as an important tool for creating awareness of the importance of surveillance among stakeholders. Political commitment was mentioned in the literature as a component of surveillance implementation that reflected the support of the high level administrators. It was described in the Peruvian EDSSIM as "commitment to ownership." Legislation and financial commitment were concepts described in similar ways by both methodologies, but more extensively by the electronic disease surveillance systems implementation model. In the gray literature, the concept of "coordination" was described by two concepts: "development of partnerships and networks" and "communication." "Development of partnerships and networks" with public and private agencies for resource mobilization, formulation of training policy, and development of standard and guidelines required strong coordination mechanisms. "Communication" among the different stakeholder groups involved all levels of the health system. The "development of partnerships and networks" in the gray literature

review also addressed part of the "technical assistance" concept, by describing the support derived from partnerships with international organizations. A component of the concept in the model of "value and action" was addressed in the gray literature review by the "surveillance strategy" concept. Consistent with the model, authors of the gray literature underscored decision makers' use of disease surveillance information and the importance of identifying the utility of the system in the early stage of the implementation process.

The gray literature review contributed to insights germane to the high administrative level by adding the important concept of having a "strategic vision" to ensure an organization's priorities were addressed when a system was implemented. Moreover, the gray literature results noted the importance of moving from a vertical systems approach toward the integration of surveillance activities into the organization. An additional concept contributed by the gray literature that was consistent with the Peruvian EDSSIM was the need for an adequate organizational structure with clear roles and responsibilities for surveillance within the system.

Comparison to the expert consensus workshop

Findings from the expert consensus workshop concurred at the administrative level with the concepts of the Peruvian EDSSIM either by fully or partially describing them. The concept of "organizational need" was partially described by workshop participants as the determination of an organization's motivation and direction. The "usefulness at all levels" concept covered in part the concept of "value and action" in the model, indicating that recognition of the importance of information generated by the system would be the first step to action that was based on that information. The experts

described "commitment to ownership" as strong executive support and "political will." Legislation, technical assistance, and financial commitment were concepts fully agreed upon by both methodologies. Conversely, the "coordination" concept elaborated on in the model was only partially addressed in the workshop report by acknowledging the need to secure and share the surveillance data.

The expert consensus workshop contributed important concepts to the highest administrative level of the Peruvian EDSSIM. For instance, the value and need for a "strategic vision and plan" coincided with the gray literature review results. The experts agreed on the importance of developing a strategic plan that included monitoring and evaluation, workforce development, and steps to sustainability. This plan, according to the consensus workshop, should be developed after the implementers had performed an assessment of country readiness for an electronic disease surveillance system, including the infrastructure and capacity of the organization to support such a system. Another element the experts recommended to be considered at this level is to start with a pilot or demonstration project to ensure acceptability of the system before expanding the system.

Table 6: Comparison of triangulated concepts at the ADMINISTRATIVE LEVEL.

ADMINISTRATIVE LEVEL – PERUVIAN EDSSIM	ORGANIZATIONAL NEED	AWARENESS OF THE SIGNIFICANCE	COMMITMENT TO OWNERSHIP	LEGISLATION, DETAILED DIRECTIVE	FINANCIAL COMMITMENT	COORDINATION	TECHNICAL ASSISTANCE	VALUE AND ACTION
Systematic literature review		Engaging key stakeholder groups	Program leadership, AND Political environment	Accountability policies	Donor and external support			Capacity building
Gray literature review		Advocacy	Political commitment	Legal framework	Financial commitment; donor's support	Development of partnerships and networks; Communication	Develop of technical assistance through partnerships and networks	Surveillance strategy
Experts consensus workshop report	Determine the country's motivation and direction; identify the country surveillance needs		Political will; Strong executive support	Legislation	Consider sponsor financial support	Coordination to ensure data transparency	Short and long term technical support	Usefulness at all levels

At the surveillance staff level

Comparison to the systematic literature review

At the surveillance staff level, the systematic literature review identified the elements of "training," "program flexibility," "human resources," "engaging key stakeholder groups," "social environment," and "infrastructure and capacity." "Training" characteristics such as the format of a training session, and the format of training materials were described in the literature review. The researcher explored this concept more extensively while developing the Peruvian EDSSIM. In the model, "training" was emphasized as a continuous activity that should be available to and conducted at all levels of the organization. "Flexibility" was described in the systematic literature review as an attribute of the tool used for data collection as well as the processes in place in order to increase acceptability of the system. Consistent with the model, "human resources" was noted in the literature review as the most common challenge for health program implementation. The literature review pointed to "infrastructure and local capacity" as important factors for program implementation, which were recognized in the model as the existence of appropriate resources to conduct surveillance duties. A favorable "social environment" for implementation was described as the presence of trust between the staff and a caring ethos that extended to the community. This concept intersected with the concepts in the Peruvian EDSSIM of "awareness of the importance of surveillance," "creation of an on-site surveillance team," and "support by the national and regional teams."

The systematic literature review did not posit the concepts of "simplicity" and "standardization" that were included in the model, which might be due to the fact that the review on health related programs implementation only included three papers that

reported on disease surveillance systems experience. One of the papers that specifically addressed surveillance systems in the systematic literature review addressed the training on data analysis.

Comparison to the gray literature review

There was strong concurrence between the gray literature at the surveillance site level and those identified in the model. While the model provided a more extensive explanation and analysis of concepts at this level, the researcher identified similarities in both methodologies. The "human resources" concept in the gray literature comprised the "skilled and motivated human resources" concept in the electronic disease surveillance systems implementation model. The organization of the system (director's support), resources, surveillance tool, (simplicity), flexibility, and standards and guidelines were important concepts at the surveillance site level. The concepts of "simplicity" and "flexibility" specifically related to the surveillance tool in the gray literature review, whereas the model addressed these two concepts in surveillance processes as well.

An important contribution by the gray literature review was the "data analysis" concept. Authors of publications in the gray literature considered "data analysis" a key element at the surveillance site level, as this skill would empower surveillance staff to understand the data collected and appropriately respond to the information generated. The lack of this concept in the model might be due to the marked emphasis in Peruvian surveillance systems studied to assure that reporting occurred in all sites. Even when there was recognition that data analysis skills are important for the reporting staff, the main objective of the implementers was to first have a high reporting rate.

Comparison to the expert consensus workshop

There was strong concordance between the expert consensus workshop and the electronic disease surveillance systems implementation model at the surveillance site level. The "skilled and motivated human resources concept" in the model was explained by experts at the consensus workshop by the concepts of "trained and available workforce," and the development of a "performance improvement plan" aimed to motivate surveillance staff. The "resources" concept in the model was linked to "financial commitment" factor explained during the workshop as a commitment that would assure that the resources needed were in place for the implementation of the program. The system's "flexibility" and "simplicity" concepts in the model were noted by the experts as a system that was "flexible and adaptable," and "intuitive to users."

The consensus workshop experts did not mention the concept of "director's support" or "standardization" of the guidelines and processes. However, the participants identified data analysis training as one of the main gaps in the developing world.

Table 7: Comparison of triangulated concepts at the SURVEILLANCE SITE LEVEL.

Surveillance site – Peruvian EDSSIM	Human resources skilled	Human resources motivated	Awareness of significance	Director's support	Resources	Simplicity	Flexibility	Standardization
Systematic literature review	Staff turnover	Lack of motivation	Engaging key stakeholder groups"	Social environment	Infrastructure and local capacity		Program flexibility	
Gray literature review	Greatest barriers; emphasize data analysis skills	Team work; commitment of reporting staff	Human resources	Organization of the system (clear roles and responsibilities of the site director)	Adequate resources (laboratory)	Surveillance tool; simplicity of the surveillance task	Surveillance tool; surveillance strategy	Standards and guidelines
Experts consensus workshop report	Trained and available workforce	Performance improvement plan to incentivize surveillance staff			Financial commitment	Intuitive to end-users	System flexible and adaptable	

The national and regional team organizational level

Comparison to the systematic literature review

At the national and regional team level of organization, the researcher identified subcategories that emerged from the systematic literature review as "training," "human resources," "engaging stakeholder groups," "infrastructure and local capacity," "monitoring and evaluation," "supervision," "communication," and "incentives". The "communication" subcategory from the literature review mainly described "feedback mechanisms" used to inform staff about their performance, as well as the "coordination" required between levels of the program. The researcher identified both "feedback" and "coordination" in the model. "Engaging stakeholder groups" was described in the systematic literature review as the closest subcategory to the model concepts of "motivated staff" and "awareness of the significance." "Engaging stakeholder groups" at all levels of the systems consisted on motivating staff and educating stakeholders on the importance of surveillance in order to achieve commitment.

One concept that deserves further explanation is "accountability policies". Both the systematic literature and grey literature reviews indicated that a lack of mechanisms for accountability could jeopardize program implementation. While the EDSSIM reflected recognition of the importance of having legislation in place, as a means of staff accountability for surveillance reporting, it was advised that implementers act with caution. Data that informed the model revealed that surveillance staff appreciated steps taken to notify them about a lack of reporting before strict measures were taken. Surveillance staff members were limited in number and had many other competing duties. Therefore, the national and regional teams were advised to investigate the reason for reporting problems. According to these data, initiating strict measures

led surveillance staff to resent the national team. It also meant that they sometimes engaged in reporting only due to fear to being sanctioned.

The use of incentives was another concept that was not consistent among the three major sources of data. Both the systematic literature review and the gray literature review, for instance, recommended the use of financial and non-financial incentives for adherence to surveillance program duties. Conversely, experts involved in the consensus workshop and data that informed the Peruvian EDSSIM agreed on using only non-financial incentives because of the program sustainability issues in a resource constrained setting.

The systematic literature review did not reveal any additional concepts at the national and regional team level.

Comparison to the gray literature review

At the national and regional team level, there was strong concurrence between the gray literature review and the electronic disease surveillance systems implementation model on concepts of "human resources skilled and motivated" with the gray literature review emphasizing the analytical skills of this group. As for "resources," "training," "monitoring and evaluation," "supervision," and "feedback" the results were similar. The discordances found in the concepts of "accountability policies" and "use of incentives" are described above.

The gray literature review did not add any further concepts at this level.

Comparison to the expert consensus workshop

At this level, during the consensus workshop the experts discussed a few concepts that comprised the ones described by the electronic disease surveillance systems implementation model. For instance, the "training" concept in the workshop applied both for the presence of "trained and available human resources," and to the specific "training" concept. The

"performance improvement plan" as explained during the consensus workshop, recognized the "motivation" component, the "feedback" functions, and the "use of incentives" at this level. The monitoring activities were described by both methodologies, and the resources concept was linked to the financial commitment concept defined by experts.

The concepts that were not mentioned during the expert consensus workshop were the accountability and the supervision concepts.

The experts' consensus workshop did not add any additional concepts at this level.

Table 8: Comparison of triangulated concepts at the NATIONAL REGIONAL TEAM LEVEL.

National and regional team	Human resources skilled	Human resources motivation	Resources	Training	Monitoring	Supervision	Feedback	Accountability might decrease motivation	Incentives
Systematic literature review	Training and Human resources	Engaging stakeholders	Infrastructure	Format of training; training material	M&E system: limit number of indicators	Supervision of all aspects of the program	Communication with the staff about their performance	Lack of accountability found to be a problem	Use or lack of incentives
Gray literature review	Emphasize data analysis skills	Team work	Adequate resources	One of the key factors, sustainable strategy	Monitoring critical to identify the progress	Supervision to maintain and improve performance	Feedback: newsletters, bulletins, reports; Communication	Lack of accountability as a problem	Use of financial and non-financial incentives
Experts consensus workshop report	Trained workforce, local champion	Performance improvement plan to incentivize surveillance staff, local champion	Financial commitment	Trained workforce, Development plan	Monitoring of the system		Feedback process included in performance improvement plan		Performance improvement plan included incentives

Advantages of using Grounded theory model in this study

The grounded theory methodology was fundamental to understanding the complexity of the factors related to the implementation of disease surveillance systems and to fully describe the relationships of these concepts at every level of the model. Through this methodology the researcher was also able to identify concepts not recognized by any other methodology used in this study.

At the Administrative level, concepts such as "organizational need," "awareness of the significance," and "value and action" were only fully characterized using grounded theory methodology. Some of the characteristics of the "organizational need" concept were briefly described by the experts' consensus workshop. This included the importance of determining the country's motivation and direction, and identifying the country surveillance needs.

Different dimensions in the concept of "awareness of the significance" were described by the three other methodologies, failing to fully characterize it. The systematic literature review identified "engaging key stakeholders groups" at the high administrative level, while the grey literature review highlighted the importance of using "advocacy" for the surveillance system at this high level as well.

The "value and action" concept that links two of the levels in the model was understood in some of its dimensions by the three other methodologies. The systematic literature review reported the importance of the action component by recognizing capacity building as one of its subcategories. One of the documents in the grey literature review noted the importance of acting on the information collected as part of their surveillance strategy. The experts' consensus workshop report included the value

component of this concept by acknowledging the importance of having a system useful at all levels, which included the administrative and the surveillance site level.

At the surveillance site level, the grounded theory methodology revealed the director's support concept that the other three methodologies failed to capture. However, the systematic literature review discussed "social environment" as an important consideration. This subcategory described the importance of trust among the staff who worked in the program. The gray literature review pointed to the organization of the system as a key element related to the director's support concept. This review emphasized creating an adequate organizational structure with clear roles and responsibilities, as well as developing team spirit and trust among stakeholders.

At the national and regional team level, the electronic disease surveillance systems implementation model made an important clarification regarding the accountability concept that other methodologies failed to identify.

Concepts added to the model

The systematic literature, the gray literature review and the experts' consensus workshop were essential to confirm and validate the concepts identified by the electronic disease surveillance systems implementation model. However, these methodologies also proved useful to identify concepts that did not arise with the electronic disease surveillance systems implementation model.

At the administrative level, the gray literature review and the experts' consensus workshop reported on the concept of "strategic vision and plan" as an important addition to this level. Both methodologies agreed on the criticality of having a strategic vision and plan to ensure the system was implemented following the organization's interests and

needs, and therefore facilitate country ownership of the system. At this same level, the gray literature emphasized the importance of prioritizing the list of diseases under surveillance. Prioritization of the list of events under surveillance was discussed within the simplicity concept at the electronic disease surveillance systems implementation model. However, this finding supported the decision of identifying "prioritization of events under surveillance" as a distinct concept. Finally, the gray literature added the concept of developing an adequate organizational structure for the system by outlining clear roles and responsibilities for every level of the model. The researcher included this concept at the administrative level since the development of these roles occurs at this level.

At the surveillance site level, all three methodologies concurred on the inclusion of the data analysis concept. While the three methodologies concurred with the electronic disease surveillance systems implementation model on the need for data analysis training at this level, the gray literature review expanded on this concept by highlighting the importance of developing automated analysis features within the tool and the provision of clear technical guidance to facilitate this function for the surveillance staff. Based on this finding, the researcher decided to describe the data analysis as a concept beyond the training aspect of it.

At the national and regional team level, no new concepts were identified by the other three methodologies.

In summary, the new revised model included two more concepts at the high administrative level (Figure 12), and two more concepts at the surveillance site level (Figure 13).

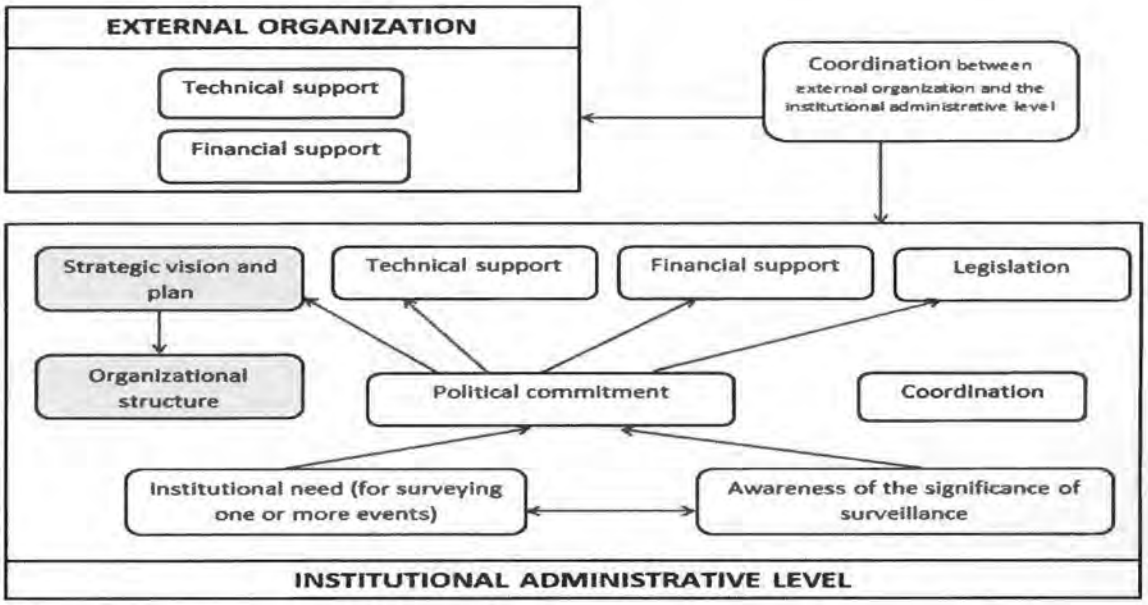

Figure 12: Institutional administrative level of the revised model. In yellow the concepts added after triangulation of data sources.

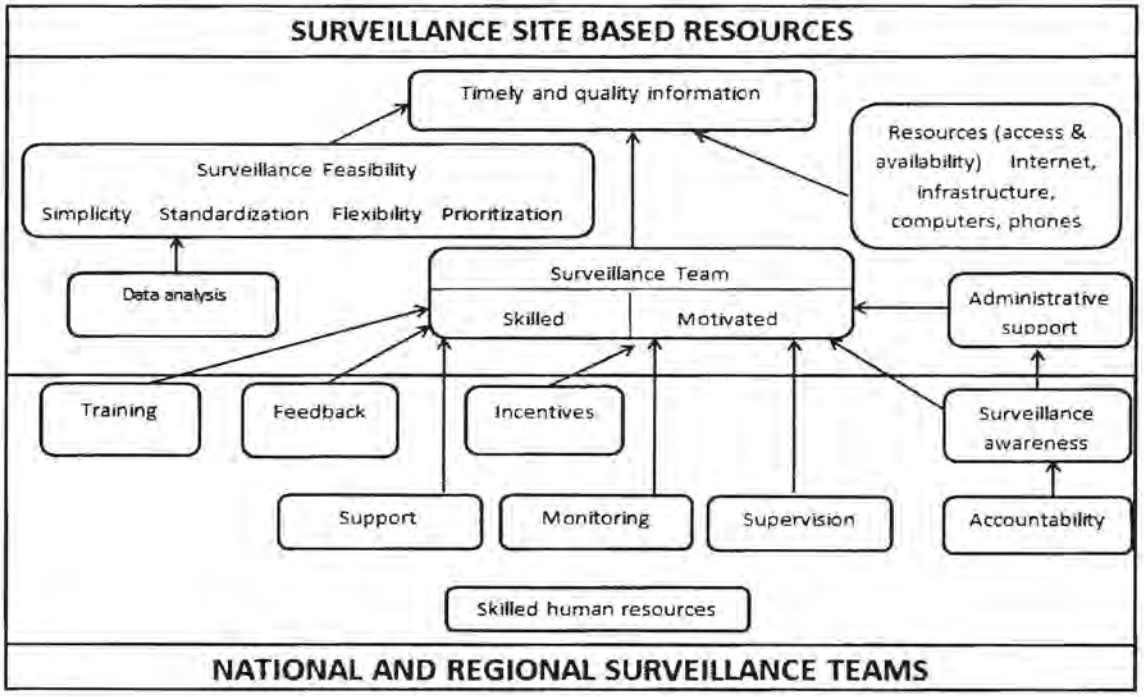

Figure 13: Surveillance site level and National and regional team level of the revised model. In yellow the concepts added after triangulation of data sources.

Recommendations

The revised electronic disease surveillance systems implementation model presents key elements to consider when there is either a need to implement an electronic disease surveillance system in resource limited settings or a desire to assess a system already in place. This study advises:

1. The administrative authorities at the institution or organization where the system will be implemented must be committed to the system. To achieve this commitment, epidemiology leaders or in some cases external organizations need to advocate for the importance of the surveillance system, and demonstrate this system is truly needed by the institution or organization. Education on the importance of

surveillance is often required to develop awareness at this level and ensure commitment to the full implementation process and ultimately the sustainability of the system.

2. Implementers need to ensure that the institutional administrative commitment achieved for the disease surveillance system translates into the following actions:
    a. The development of a strategic vision and plan that reflects the real needs of the organization and maps out the sustainability strategy for the disease surveillance system. This plan should include a monitoring and evaluation framework and an articulated workforce development plan.
    b. The creation or update of legislation to support the implementation and functioning of the disease surveillance system that also provides a means of accountability of the required processes and tasks. The content of this document must include the organizational structure of the system with clear roles and responsibilities for each level, all the processes required, the monitoring and evaluation activities of the inputs, processes and outcomes, and the use of the information. This document should also explicitly describe the coordination mechanisms within the different levels of the organization, between organizations that perform similar or complementary surveillance activities within the same the institution, and between the institution and the external organizations providing technical and/or financial support.
    c. The administrative level should ensure the financial support required for the implementation process by committing the institution to the required funding, by identifying an external donor, by establishing collaboration efforts with

other institutions, or by using a strategy that combines them. The amount and duration of this support should be clearly stated.

d. Adequate technical support has to be secured for the implementation of the system, either by assigning skilled staff from the institution or through an agreement with an organization that provides the expertise required.

e. The administrative level should guarantee the dissemination of this document to all stakeholders' groups and surveillance sites. The implementers' team may use this document as an important tool to create awareness of the importance of the disease surveillance system being implemented and to demonstrate the commitment of the highest authority in the institution to the system.

3. The implementers must ensure that there is a surveillance network composed of national, regional and if feasible district surveillance teams. The national team must be a skilled and motivated group with strong commitment to the implementation of the system. This team should use a top down approach to train and educate the lower level teams and instill the same level of commitment. These lower level teams once trained will be directly responsible for the activities required to prepare fully functioning surveillance sites within their jurisdiction. The national team is directly responsible for ensuring the high authority level stays committed and supports this process, as well as to respond to the needs of the lower level regional and district teams. The regional and district surveillance teams are responsible for directly responding to the needs of the reporting staff at the surveillance sites or by requesting assistance at the national level.

4. The national surveillance team must ensure that the following functions are performed to support the reporting staff at the surveillance sites:
    a. Following the monitoring and evaluation framework, the national or regional team must make sure all the processes to generate the surveillance information are taking place. This monitoring activity should be used to increase the quality of the data by identifying the retraining needs of the personnel, and refinements required in the surveillance processes and the surveillance tool.
    b. The information generated should be used to provide feedback of their activities to the surveillance staff and the high administrative level and as proof of the usefulness of the system, which contributes to the continuance of support.
    c. Through the monitoring and evaluation activities, sites should be prioritized for supervision. The supervision visits represent an opportunity for retraining surveillance staff; learning the reality of the site, its challenges and opportunities; and developing a close relationship with reporting staff to improve future communication.
    d. The national, regional, and district teams should represent a support source for the reporting staff at the surveillance sites. Therefore, sanctioning for lack of timely reporting should be left as a final resource. Learning the reasons for low performance and addressing them encourages reporting staff to confide the obstacles faced and surpass them.
5. The regional and district surveillance teams in coordination with the national teams should prepare on-site functional surveillance teams at every site instead of

assigning this task to a few people. These local surveillance teams need an adequate environment to function, the skills required to perform the surveillance tasks, the motivation to conduct this task, and a feasible task considering their other multiple tasks.

6. The provision of an adequate environment for the reporting staff include providing the resources required to perform the task, and creating awareness of the significance of the disease surveillance system in all health care personnel including the director of the surveillance site to support this task.
    a. Maximizing the use of the resources already in place is critical, either by identifying the resources, updating them or securing the administrative permits that guarantee the reporting staff has access to them. Developing collaborations with other surveillance efforts within the same institution or external organizations has proved to be an effective strategy to secure resources and to increase the efficiency of its use.
    b. Educating health care personnel on the importance of the task conducted by this onsite team is crucial to create an environment of support at the surveillance site level.
7. The provision of the adequate skills requires a continuous and comprehensive training strategy tailored to the needs of the reporting staff. Innovation in the delivery strategies is especially needed to be able to reach the surveillance staff even in the most remote areas and give a better use to the resources available. Data analysis skills should be a priority once the reporting staff is comfortable with using the system.

8. A performance improvement plan must be in place to ensure the level of motivation of the staff remains high. Finding the right incentives that can become a sustained practice is essential for the morale of the staff. However, receiving feedback with the data generated, the training received, the support from the higher level teams when outbreaks are identified, and working in an environment with support and recognition of the importance of the tasks performed are important contributors to the motivation of the reporting staff.
9. The surveillance task has to be feasible for the reporting staff considering their skills, resources and competing tasks. It is crucial that the process and the tool used to collect and analyze the data are simple to use, flexible to changing circumstances and surveillance needs, and standardized to all surveillance sites. The list of events has to be prioritized to select not only the number of events but also the amount of data to be collected.
10. Finally, a fully functioning system needs to use the information generated to put in place public health measures to improve the health of the population under surveillance. This is the ultimate motivator for reporting staff and staff at the district, regional and national levels.

Future research

This study developed a model to understand the key considerations when implementing electronic disease surveillance systems in developing countries. Due to the scarcity of published literature on implementation of electronic disease surveillance systems, this effort primarily relied on qualitative research methodology. The next step would be to identify and create quantitative metrics or benchmarks for the concepts in the

model to be able to measure the probability of success of the implementation of a surveillance system in such settings.

This model focused extensively on the reporting side of the surveillance system, as in developing countries the main concern is to have a system that generates data. However, further research needs to explore systems where there is a greater use of the data at the national and regional levels. This would allow obtaining the maximum benefit of the information generated and develop a better response to it.

This model was developed using data from civilian and military institutions, but identifying implementation factors in common for both of these institutions that could be extrapolated to other institutions. However, it would be appropriate to explore the divergences of both realities to develop recommendations that are specific to each of them.

Finally, the first version of this model was developed based on the data collected in Peru, and then it was validated by literature from other developing countries, as well as from the experience of experts who have worked in several developing countries. Nevertheless, it would be important to apply this model to systems in countries with resource constraints different from Peru, in order to fully understand the applicability of the model.

SUMMARY AND CONCLUSION

To build an initial model to understand the successful implementation of electronic disease surveillance systems, the researcher used grounded theory methodology to analyze data collected from disease surveillance stakeholders from the MOH and the Armed Forces, as well as from foreign organizations that supported this process in Peru. The concepts identified in the model were triangulated with the findings in the published and grey literature and the consensus reached by subject matter experts on a workshop organized by the researcher in Washington, DC. The final revised model is presented in Figure 14.

There are major lessons learned for electronic disease surveillance system implementation, monitoring and evaluation from this research. The success in the implementation of these systems was conceived by the confluence of several factors at different levels of stakeholders: at the institutional administrative level, at the national and regional disease surveillance team level and at the surveillance site level.

At the administrative level, the key element to start this process was the recognition of a surveillance need in the organization and the awareness of the significance of this need. The administrative level will then commit to implement and sustain this program through the development of a strategic vision and plan, the establishment of an organizational structure of the system, the development or update of surveillance legislation, and the assignment of financial, technical and other resources required to conduct this process. An external organization may play a role in this process by providing technical and additional financial assistance and if that is the case,

coordination mechanisms have to be put in place to maximize the collaboration between these organizations.

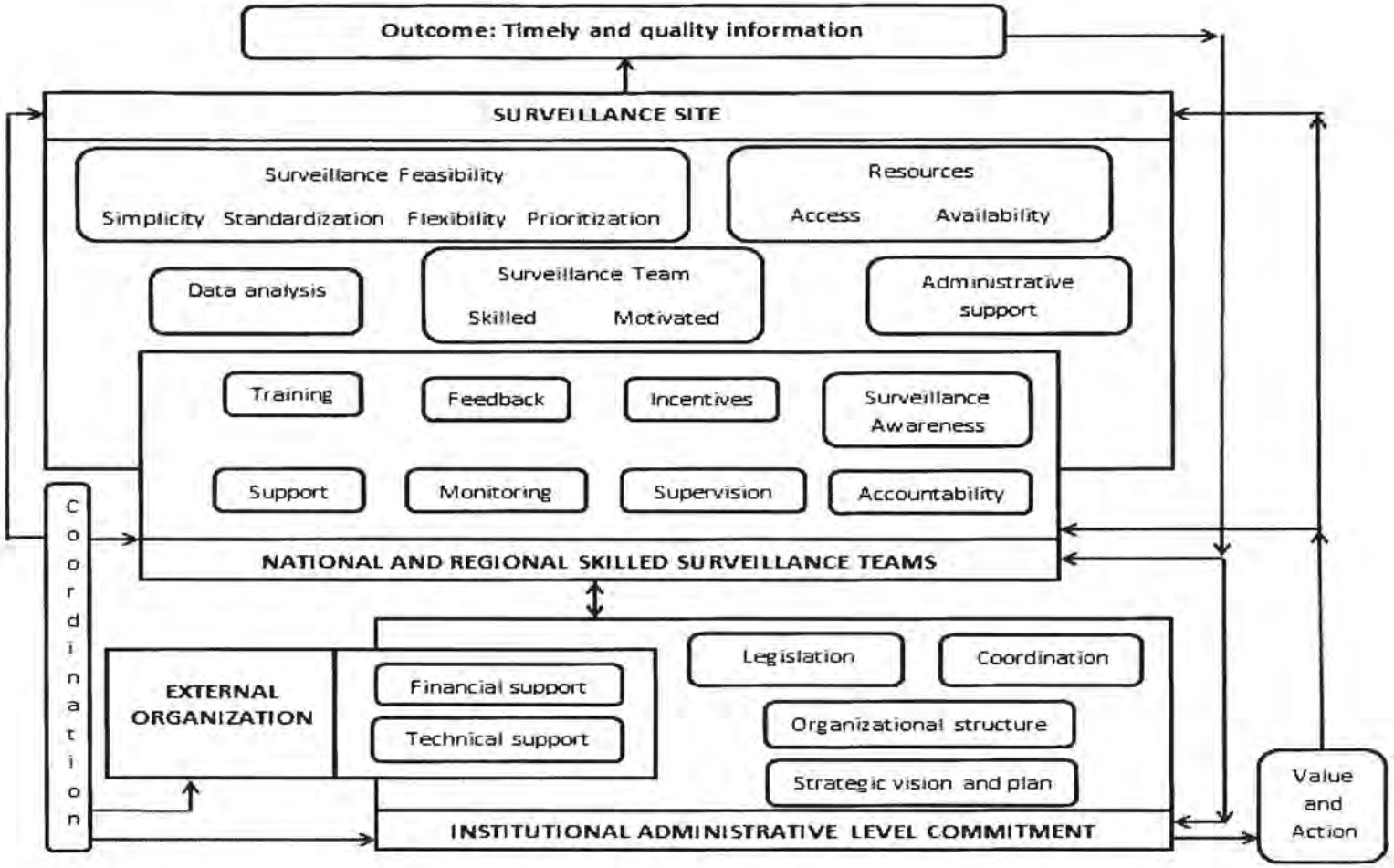

Figure 14: Final revised model for implementation of electronic disease surveillance systems in resource limited settings.

The national disease surveillance team, often in collaboration with the regional teams, takes charge of operationalizing this process. This team should be composed of highly motivated people with experience in disease surveillance. The main functions for these teams are to train the reporting staff; monitor the timeliness and the quality of the data generated by the reporting staff; and give feedback with the analysis of the data collected by the system to the administrative level and the surveillance staff. Supervision was also found important in improving the quality of the data and as a means to build a closer relationship with the reporting staff and strengthen their commitment. The resources required to perform these functions were critical.

An important concept in the model is the availability of skilled and motivated human resources at the surveillance sites. Training played a duplicative role in providing the skills required for the reporting staff to fulfill the surveillance tasks, as well as to increase the awareness of the significance of this task. This increased awareness was considered a motivator by itself. In addition, motivation was increased by: having the resources in place to perform the task (i.e. computers or phones); the support from the director of the site who facilitated the task (i.e. allowing the use of the only computer at the site); the constant support and response to the events reported from the national team (i.e. response to outbreaks reported); the feedback received with the analysis of the data collected (i.e. monthly bulletins); and the use of incentives, such as the recognition of the best performing sites by the highest authority in the organization. One final concept to consider at this level, in order to facilitate the reporting staff to provide timely and high quality data, is the feasibility of the surveillance task. For this task to be feasible, the reporting process and the reporting tool should be simple and flexible, and the materials and guidelines standardized and clear. The tool can be designed to facilitate the reporting for the

surveillance staff and the monitoring tasks for the national and regional teams. Finally, the data generated by the system needs to guide decision makers to put in place preventive actions for the improvement of the health status of their population. To enhance the health of their population was recognized as the main motivator for all groups of disease surveillance stakeholders.

It is noteworthy that the first review of the literature that focused on the implementation of health programs in developing countries identified several important concepts that were included in the final model developed specifically for electronic disease surveillance systems. Even when these concepts were not well developed in the literature, they served as an initial guidance and reference. Key factors identified with this initial literature review were: political environment, leadership, legislation in place, external support, monitoring, supervision, training, communication and engagement of stakeholder groups, program flexibility, human resources and other resources, motivation, and social environment.

The second review of the literature, which specifically targeted electronic disease surveillance systems in developing countries, revealed most of the concepts identified in our interviews. Moreover, the consensus reached by experts on this field on the key factors related to the successful implementation, provided the confidence to the researcher that the model developed was coherent and supported by other similar experiences. However, the relationship between those concepts could not be assessed and fully explored by these methods. The use of grounded theory methodology proved critical for this purpose.

Several limitations should be recognized about the work presented. This work is qualitative which intrinsically means that it is strongly dependent on the researcher's skills and her biases. The researcher had extensive work experience on disease surveillance implementation in Peru which was an asset to understand the data, but at the same time could bias the ideas and

experiences presented by research participants. To be able to prevent this or correct it, the researcher kept a personal journal to document the research process.

An additional limitation relates to the sampling methodology. Due to regulatory requirements, the researcher could only contact the potential research participants twice in recruitment efforts. This restriction prevented interviewing some identified stakeholders. When this situation arose, the researcher found replacement participants from the same stakeholder's group with similar characteristics and experience. Due to logistic limitations, most of the interviews took place in the capital city. However, the people selected to be interviewed had worked in several sites across the country, including remote areas, allowing the researcher to capture this information as well.

Despite the limitations described above, the researcher believes this is the first step for developing a model with the ability to predict successful implementation of electronic disease surveillance systems in settings with resource constraints. This exploratory study can serve as the basis for future research to test the model in other realities and then create variables that can actually be quantified. Being able to predict if the implementation of a program will be successful can greatly serve for better allocation and use of resources. Moreover, such a model may empower decision makers from governmental and non-governmental organizations that support these initiatives and be able to identify places for improvement to guarantee success in this process. Last, the researcher believes this model constitutes an initial tool to understand program implementation of other health related programs in developing countries.

Appendix A: Systematic review methodology

The researcher and her thesis advisor (CM, RWG) developed the research protocol followed in this study. The protocol and subsequent study was designed using the PRISMA statement format (58; 67).

To be included in this systematic review, studies had to meet the following criteria: 1) be indexed to one of the selected information sources, 2) be written in English, 3) be focused on a developing country(ies), and 4) must have addressed the implementation of a specific health-related program. There were no restrictions on date of publication, specific research methods, focus of intervention, or outcome measure(s) addressed. Opinion or commentary manuscripts were excluded only if they did not meet the four criteria outlined above.

Studies were identified by searching the following electronic databases: PubMed (1957-2008), embase® (1974-2009), CINAHL® (1976-2009), PsycINFO® (1967-2009), and Current Contents Connect® (1975-2009). The last search was conducted on 25 March 2009. The researcher conducted an initial search using the following key word scheme (using the embase® example): (('program evaluation'/exp OR 'program evaluation') OR ('program development'/exp OR 'program development') OR ('pilot projects'/exp OR 'pilot projects')) AND (('health promotion'/exp OR 'health promotion') OR ('population surveillance'/exp OR 'population surveillance') OR ('health education'/exp OR 'health education') OR ('health policy'/exp OR 'health policy')) AND (('biomedical technology'/exp OR 'biomedical technology') OR ('information dissemination'/exp OR 'information dissemination') OR ('public health informatics'/exp OR 'public health informatics')) AND (('developing countries'/exp OR 'developing countries') OR 'global' OR 'provincial' OR 'rural' OR 'regional').

Upon completion of the first search, using above criteria, the researcher and her advisor determined that the initial search criteria was too tight, resulting in potential loss of important studies. The researcher conducted a second revised bibliographic search using broader key words: 'implementation' AND 'global' AND 'health'. The researcher anticipated that the revised search criteria would yield additional studies for review; many without a focus on technology or defined program structure. The potential gain of new information, however, outweighed the cost of reviewing additional abstracts.

Study eligibility assessment within each bibliographic search was performed independently by both the researcher and her advisor in an un-blinded standardized manner. Results of the reviews were compared and disagreements were resolved through a consensus process. Specifically, the person opting for inclusion would present the abstract to the other person, and defend why the manuscript should be included. Discussion would ensue until consensus was reached on inclusion or exclusion of the abstract.

In preparation for the review, the researcher developed a single data extraction instrument (see Appendix B). The instrument was initially pilot tested by CM and RG on 10 papers, then revised to clarify confusing points and eliminate unnecessary elements. The researcher conducted the bibliographic searches using the identified electronic databases, per protocol, and provided a copy of all results to her advisor (RWG) for concurrent review. In the initial stage of abstract review, the researcher and advisor used the study selection criteria as a basis for determining if full review was appropriate. When full review was warranted, the researcher obtained the full-text version of the manuscripts and provided a copy of each to her advisor. CM and RWG extracted data from each full-text manuscript to the extraction instrument, assessed its applicability, and made an independent evaluation of its inclusion in the systematic review. Both

the researcher and her advisor reviewed their extraction forms collectively, and came to consensus regarding which manuscripts would be ultimately included.

The data extraction form included specific inclusion criteria and descriptive information on the study. Key dimensions of program implementation were documented qualitatively. Basic qualitative coding methodology was applied to the documented dimensions in an effort to identify key themes used in reporting the findings. While the themes were identified after completion of the review, the following data items were adopted from the work of Paul-Ebhohimhen and colleagues (73) and served as the basis for the format of the tables (See Appendixes C, D, E, and F). They include: 1) reference, 2) sample characteristics, 3) details of intervention (including objective), 4) study design and analysis, and 5) important observations/considerations.

Research on program implementation within developing countries is traditionally descriptive in nature and often lacks tight controls to reduce bias. As such, the researcher did not apply specific criteria in assessing risk of bias within individual studies.

Appendix B: Health-related Program Implementation Systematic Review Abstract Evaluation Form

First author, year published: _____

Basic Inclusion / Exclusion Criteria:

Article related in some manner to program implementation?
____Yes _____ No [EXCLUDE]

Written in English: ____ Yes _____ No [EXCLUDE]

Focused on implementation in developed countries.? _____ No _____ Yes [EXCLUDE]

Type of article:

___ Research (including education research)
- ___ Systematic review
- ___ Program evaluation/quality improvement study
- ___ Commentary/opinion paper/perspectives paper
- ___ Education paper (describes curriculum, assessment, etc.)
- ___ Other (specify: _____ _____)

KEY DIMENSIONS OF PROGRAM IMPLEMENTATION ADDRESSED OR STUDIED: (List. If none, exclude)

POSSIBLY INCLUDE STUDY IN SYSTEMATIC REVIEW: _____ Yes ___ No
If not, why not?

Setting:

Number of Sites	_____
Number of district/provinces	_____
Number of Countries	_____
Number of regions	_____
Number of rural sites	_____
Number or urban sites	_____

Type of Setting:

Community or family based	_____
School-based	_____
Clinic/hospital based	_____
Employer-based	_____

If research, type of study:

____ Observational descriptive
____ Observational analytic:
- _____ Cross-sectional
- _____ Cohort
- _____ Case-control
- _____ Ecologic

____ Experimental or quasi-experimental
____ Tool development and/or validation
____ Other (specify: _____)

If research, data collected:

____ Chart review (paper or electronic)
____ Survey/interview: self-administered
____ Survey/interview: administered in person by interviewer
____ Survey/interview: administered by email or phone
____ Participant observation
____ Focus groups/community forum
____ Outcome variables measured (specify: _____)
____ Other: _____

If systematic review:

Type:
- _____ Summaries or descriptions
- _____ Meta-analysis
- _____ meta-synthesis

Purpose:
Number of papers reviewed/included:
Summary of findings:

If program evaluation or quality improvement,

What was evaluated?
What is the "level" of the evaluation data?
- _____Patient or user satisfaction
- _____Behavior change
- _____Process
- _____Impact (intermediate outcomes)
- _____Long-term outcomes
- _____Formative evaluation
- _____Summative evaluation
- _____other: _____

Appendix C: Summary of included studies related to Program Design

Reference	Sample characteristics	Details of intervention	Study design and analysis	Important observations (primary)	Important observations (secondary)
Asbroek et al. 2005 (4)	Governmental primary health care centers, health posts and sub-health posts of Nawalparasi, a rural lowland district in Nepal.	Practical Approach to Lung Health (PAL)-Nepal is an adaptation of generic PAL WHO guidelines. *Objective*: to improve syndromic management of lung diseases in youths >5 yr and adults of middle-low income countries. Includes clinical practice guidelines and training materials. Implementation strategy consisted of training primary care health workers using didactic presentation and interactive exercises.	*Study type:* Qualitative assessment of the development and implementation process. Assessed three components: guidelines, training, and context of health workers. *Analysis*: Multi-rater kappa analysis and qualitative analysis.	*Program design*: 1) Training materials of high quality, 2) Easily accessible, comprehensive guideline document, 3) Training schedule doesn't compensate for turnover, 4) Algorithms are many and complex, 5) Training not modified to match worker qualifications/capabilities, and 6) Training alone is not effective.	*Engagement:* 1) Stakeholder involvement (patients views not incorporated). *Accountability/leadership:* 1) Lack of recommendations for monitoring and auditing. 2) Limited recognition of human resource barriers. *Environment*: 1) Powerful stakeholders at national level and international donor support, 2) Positive results necessary to marshal political will and financial resources, and 3) High staff turnover and absenteeism.

Valenciano et al. 2004 (91)	ALERT initially in 4 pilot districts then expanded across Serbia over a 6-month period. All 25 districts and 156 municipalities (98%).	ALERT is a communicable disease surveillance system that relies on notification of 11 syndromes by primary care facilities. Data are analyzed weekly at district level and transmitted to national epidemiologists where they are computerized. Public domain software used for relational data entry and production of interactive reports.	*Study type*: evaluation using CDC guidelines. Team analyzed the ALERT database, revised documents and reports, conducted structured interviews with key informants at all levels and held one-day evaluation workshop with all district epidemiologists. *Analysis*: Varied by attribute under analysis.	*Program design*: 1) System simple (data entry takes one minute per week) and flexible, 2) Using syndromic case definitions allows reporting without lab confirmation, 3) Uses standardized data at national level,4) Lack of ALERT connection with individual control measures, 5) Strengthened data analysis through training.	*Environment*: 1) Perception of ALERT as parallel system not interoperable with routine system, and 2) Acceptability higher at national level because of timely reception of data. *Accountability/leadership:* 1) Reporting procedures not incorporated in the public health laws and regulations. Engagement: 1) Program improved communication between all surveillance actors and strengthened surveillance network, 2) Improved feedback and communication at republic and district level.
Amaral et al. 2005 (2)	3 of 9 states in Northeast region in Brazil; Inclusion criteria: year 2000 population of 5,000-50,000;excluded larger and smaller municipalities; 144 municipalities (48 in each group).	*Objective:* IMCI (Integrated Management of Childhood Illness) aims to reduce leading causes of death among young children; contents: case management at health facilities, strengthening health systems support and improving family & community practices.	*Study type*: Observational study comparing 3 groups 1999-2002: High IMCI training coverage >50-60% (23 munic.); low (216 munic.); no IMCI (204 munic.); Health facility survey: 23 high IMCI munic. (48 facilities) vs. 23 NO IMCI(48 facilities); *Analysis:* ANOVA, analysis of trends.	*Program design*: 1) Training component limited to physicians and nurses, 2) Lack of association between IMCI training coverage and infant mortality after controlling for confounding variables.	*Environment:* 1) Experienced high staff turnover. *Engagement:* 1) Program improved quality of care in IMCI facilities, *Accountability/leadership:* 1)Supervision was poor
Bryce et al. 2005 (13)	12 countries restricted to those likely to implement IMCI fully in large	*Objectives:* IMCI strategy (1996-2001) aims to reduce mortality among children under the age of 5 years.	*Study type*: 7 years of country-based evaluation; Impact model developed in	*Program design:* 1) Technical guidelines on delivering interventions at family and community	*Environment:* 1) Staff turnover an impediment. *Accountability/leadership:*

	geographical areas, within the 2 years after the assessment visit (impact evaluation period of 2-3 years).	Implemented in countries with moderate to high levels of child mortality in 3 phases: 1) introductory phase: orientation meetings, trained key decision makers, management structure, 2) early implementation phase: limited geographic areas and plan for expansion 3) expansion phase.	1999-2000. 3 types of studies included: 1) 12 country in-depth assessments of IMCI implementation; 2) Compatible designs in Bangladesh, Peru, Tanzania & Uganda; each tailored to the stage and characteristics; 3) Cross-site analyses of specific activities. Studies were prospective, retrospective and mixed designs. *Analysis:* Compared findings of MCE-IMCI relative to program expectations.	levels were slow to appear, 2) Training courses required substantial organizational skill and dedicated staff, 3) Integrated guidelines supported by high quality training and supportive supervision.	1) Evaluation not weighted for health system limitations (political commitment, human resources, financing, integrated or coordinated program management, effective decentralization).
Forster et al. 2008 (37)	10 of 21 programs completed questionnaire on EMR systems, resources, reporting systems, data storage, quality control measures and tracing of patients lost to follow up; 21 sites surveyed; Africa (18), Asia (2), South America (1).	Antiretroviral Treatment in Lower Income Countries (ART-LINC) collaboration; a network of treatment sites of International Epidemiological Databases to Evaluate AIDS (IeDEA).	*Study type:* Survey used to create quality indicators. *Analysis*: Factor analysis; Reliability tests; Site data and quality compared using univariate and multivariate maximum likelihood logit models; models for clustered data were used to evaluate predictors.	*Program design:* 1) Training of staff and clerk hours spent per week per 100 patients on ART were associated with a decreased likelihood of missing data, 2) Staff inadequately trained to manage data and trace patients lost to follow up, 3) Limited number of database features, 4) Lack of standardized coding or controlled vocabularies, 5) Advantage of central server over local server is stability and security BUT raised	*Engagement:* 1) Need development of affordable and sustainable solutions to support clinical care.

				issues of data ownership, 6) Open resource databases easily adapted to local requirements, 7) Several strategies to trace patients.	
Herbst et al. 1999 (44)	1 hospital in the Northern Province of South Africa - pilot site; 42 hospitals total.	Implementation of a Hospital Information System (HIS) in 42 hospitals in Northern Province, South Africa. Began with one pilot site. Each hospital had its own application sever managing local data, but shared some patient-level data with other hospitals and to central server.	*Study type*: Formative evaluation program to assess a new information initiative in South Africa. *Analysis:* not addressed	*Program design:* 1) Training for software use by end-users effective and 2) Interventions should be sensitive to the changes of political, professional and managerial environments.	*Engagement:* 1) Enthusiasm and understanding of need for the systems at senior-level needs to be diffused down to managers and clinicians at all levels.
Huicho et al. 2005 (48)	34 health districts (DISAs) in 24 departments in Peru (1996-2000).	IMCI strategy depicts 3 components: health system improvements, health worker training and community level interventions.	*Study type:* Ecological study. *Analysis:* Bivariate analysis of key variables.	*Program design:* 1) Correlation between training coverage, outpatient utilization and vaccine coverage were weak and non-significant 2) No significant associations between clinical training and mortality or nutrition indicators.	*Environment:* 1) High turnover of trained staff.
Okubagzhi et al. 2002 (70)	Ethiopia National project	Ethiopia Multi-sectoral HIV/AIDS Project (EMSAP) finances a 3-year government strategic plan. *Objective:* To reduce the spread of epidemic, alleviate impact and increase access to treatment, care and support for those infected and affected.	*Study type:* not addressed *Analysis:* not addressed	*Program design:* 1) Manuals proven useful instruments but frequent interpretation required, 2) Conducted pilot phase with limited number of districts, 3) Manuals and training is NOT sufficient, 4) Complex design was barrier to coordination.	*Environment:* 1) Brief time to internalize implementation process, 2) International partnership instrumental in creating government interest to take urgent action, and 3) Government established a comprehensive policy and strategic plan. *Engagement:* 1) Encouraged interventions at a community level by allowing funds to flow directly to communities.

Appendix D: Summary of included studies related to accountability / leadership

Reference	Sample characteristics	Details of intervention	Study design and analysis	Important observations (primary)	Important observations (secondary)
Freedman et al. 2007 (39)	Not addressed	Outlined four major global safe motherhood initiatives: 1) Averting Maternal Death and Disability (AMDD), 2) Immpact, 3) the Skilled Care Initiate (SCI) and 4) ACCESS.	*Study type:* Description of field experiences that provide a set of central lessons-learned. *Analysis:* not addressed	*Accountability/leadership:* 1) Implementation efforts should not wait until all central issues resolved, 2) Establish legal and regulatory mechanisms to ensure accountability, 3) Define a small number of indicators that will not overwhelm fragile reporting systems.	*Environment:* *1)* Infrastructure support of health system important, 2) Donor support critical, 3) Positive social atmosphere created by local chiefs and 4) Staff at all levels viewed themselves as part of a team. *Program design:* 1) Program should be based on evidence and on relevant information about local context. *Engagement:* 1) Comprehensive framework for recruiting, developing and retaining workforce important, and 2) context specific information about motivating factors for service quality and use.
Khatri et al. 2002 (57)	National TB control program in India where health infrastructure present.	DOTS strategy expanded rapidly since late 1998 and in both 2000 and 2001 the country probably accounted for more than half the global increase in the number of patients treated under DOTS.	*Study type:* Commentary piece. *Analysis:* not addressed	*Accountability/leadership:* 1) Program orientation towards problem solving, and accountability important, 2) Regular monitoring and timely feedback critical and should be tied to funding, 3), Supervision at all levels essential, and 4) Requires specialized supervisory staff who can promote accountability.	*Program design:* 1) All technical policies and detailed training modules written and field tested, 2) Phased program expansion is essential, 3) Focus areas must be carefully selected and maintained. *Engagement:* 1) Regular interaction among all levels of staff led to large body of highly skilled and motivated workers, 2) Required building government commitment to program. *Environment:* 1) Adequate funding required as is flexibility of use.

Hotchkiss et al. 2006 (46)	Country of Georgia. Center for Public Health (CPH) office from 12 rayons (or districts) in Region of Imereti (intervention) and 3 rayons (control) participated in study.	Program to standardize and facilitate analysis of vaccine preventable disease (VPD) data and its translation into public health actions. Intervention components included: (1) Surveillance guidelines for rayon-level public health managers with surveillance handbook for health facility staff, (2) Job aid for rayon CPH offices to help guide analysis and use of VPD data, 3) Training in the guidelines for both rayon CPH and facility staff, 4) On-the-job technical assistance, and 5) Financial reimbursement system for specified analysis and response activities.	*Study type:* Longitudinal pre-post quasi experimental research design, supplemented with data from surveillance system record reviews and focus group discussions. *Analysis*: Regression modeling to assess the effect of intervention package on selected outcomes.	*Accountability/leadership:* 1) Lack of CPH authority to impose penalties on low-performing health facilities, 2) Weak accountability relationships within Georgia's health system, and 3) Lack of clarity about which level bears responsibility for key surveillance and response functions.	*Engagement:* 1) Poor reporting of data from some private providers, 2) Program led to an increased ability of CPH staff to carry out critical surveillance functions. *Environment:* 1) Lack of telephones and electricity in health facility and CPH offices was problematic, 2) Generally low levels of health care utilization in country, 3) Limitations of government resources to carry out surveillance and response.
Cutts et al.	Mozambique	Project objectives	*Study type:*	*Accountability/leadership:*	*Program design:*

1988 (25)	MOH estimated priority target population of 24,000 children aged 0-11 months and 27,000 pregnant women.	were to achieve 70% coverage of infants for all EPI (Global Expanded Programme on Immunization) vaccines and of pregnant women for tetanus toxoid. Main action points: -Simple uniform immunization schedule -Outreach visits in 3 consecutive monthly pulses. -Effective communications systems to inform villagers -Integrating EPI with MCH (maternal and child health care). -Making best use of contacts with health services.	Evaluation paper. Monitoring activities provided useful qualitative information. Baseline surveys were also performed. *Analysis:* not addressed	1) Good managerial ability, 2) Supervisory needs are high, 3) Continuous participatory process of monitoring and evaluation, 4) Definition of specific roles and concrete tasks, 5) Commitment of senior personnel for accountability.	1) Training needs are high, 2) All mid-level health workers should be trained to do tasks, 3) Printed materials are helpful, 4) Pilot phase is useful, 5) Different techniques used at different stages of program development. *Engagement:* 1) Working with people at grassroots levels, 2) Establish direct contact with peripheral level, 3) To show results at a small scale can be used as motivator, 4) Senior personnel involvement in evaluation and providing feedback can be used as motivator, 5) Face to face communications strategy was developed, 6) Plan was prepared by MOH and donor agency and discussed with provincial authorities. *Environment* 1) Sufficient human and material resources, 2) Positive attitudes of health staff and aim population.

Appendix E: Summary of included studies related to engagement

Reference	Sample characteristics	Details of intervention	Study design and analysis	Important observations (primary)	Important observations (secondary)
Albert et al. 2007 (1)	28 developing countries selected from 42 countries whose government staff participated in previous workshop. 4 case studies: India, South Africa, Chile and Guatemala (countries with highly diverse populations and a range of challenging nutrition education needs).	*Objective*: Implement food-based dietary guidelines (FBDG) - to advise the general public on nutritional information tailored for each country. Includes policy tool used to coordinate nutrition programs and to evaluate adequacy of the food supply in meeting the nutritional needs of the population.	*Study type*: Cross-sectional: survey sent by email (messages contained, organizations involved, use of FBDG, evaluation); Case studies: face-to-face interviews, telephone interviews, surveys and review of documentation, personal in-depth knowledge of processes followed. *Analysis:* Not addressed	*Engagement:* 1) Used well established channels of communication and existing training activities to promote FBDG, 2) Involvement of all relevant stakeholders at the earliest stages critical.	*Program design:* 1) Lack of data can delay the development of guidelines, 2) Flexibility and creativity important to overcome limited resource constraints. *Environment*: 1) Required political support and coordination of efforts. *Accountability/leadership:* 1) Process evaluation should consider the environment and potential for change.
De Salazar et al. 2005 (27)	A municipality of Cali that covers 4 schools with 1500 children, followed by expansion to 7 educational institutions reaching 1300 children	School-based behavioral risk factor surveillance system (SIVEA) developed by Universidad del Valle, Colombia.	*Study type:* Not addressed *Analysis:* Not addressed	*Engagement:* 1) Empowered local people and communities to manage their own system, and 2) Applied effective strategies to increase key stakeholder participation and political will.	*Environment:* 1) Successfully utilized available resources and infrastructure (including daily activity) at school. *Accountability/leadership:* 1) Advocacy, communication and advertising used to involve and motivate parties within and outside school. *Program design*: 1) Surveillance results were used in

					decision making.
EANMAT 2001 (31)	Kenya, Tanzania, Uganda and Rwanda; all countries have 8 official sentinel sites (SS) except Rwanda (4). Important selection criteria included: transmission intensity, population density, accessibility of health center, national borders, geographical spread, all for a defined catchment area and stable population	EANMAT(East African Network for Monitoring Antimalarial Treatment) to include: Intervention included support documentation/goals, standardization of test methodology and field manual, number and location of SS, monitoring of treatment, computer data entry program, internal evaluation, appointment of network manager, and policy. Each national team comprised 8 staff (4 clinical, 4 parasitologists) trained in WHO methodology. Every 2 years, meetings to discuss policy implications of data	*Study type:* Not addressed *Analysis:* Not addressed	*Engagement:* 1) Central role for MOH regarding ownership, implementation and political support, 2) EANMAT partnership with MOH contributed to beneficial attitude changes and impact on development of policies.	*Program design:* 1) Network should be built in stages (bottom-up staged development). *Environment:* 1) High staff turnover, 2) Resources and data shared through a small network (3-5 countries). *Accountability/leadership:* 1) Treatment efficacy data used in evaluation and modification of antimalarial policies, 2) Coordinating secretariat essential for project organization and to provide a subregional, malaria-specific scientific focus.
Jahan et al. 2000 (51)	Community in Chittagoing, the coastal area of south-east Bangladesh.	Community health education pilot project titled Sanitation and Family Education (SAFE).	*Study type*: Cross sectional qualitative survey. *Analysis*: not addressed	*Engagement:* 1) Development, testing and refinement of tailored education messages that target all members of a community including	

				men, women and children; 2) Interactive communication within the community led to skills development and local ownership of the program.	
Lonroth et al. 2004 (60)	4 Public-Private Mix (PPM) projects were established for DOTS implementation in New Dehli and Pune, India; Ho Chi Minh City, Viet Nam; and Nairobi, Kenya.	DOTS strategy. Educational activities for PPs were similar across projects and strongly emphasized adopting WHO recommended diagnostic and case management principles.	*Study type*: evaluation study. Projects evaluated within a framework developed by WHO with the aim of enabling cross-project analysis; *Analysis:* qualitative analyses of interview and written project documentation.	*Engagement:* 1) Access to diagnostic facilities, educational activities and supervision were incentives to encourage participation, 2) Direct financial incentives were NOT associated with improved diagnosis or treatment.	*Accountability/leadership:* 1) Improved referrals and information systems via simple practical tools, 2) Stakeholders engaged in active dialogue beginning 18 months before the project was launched and throughout the project. *Program design*: 1) Generic model should be adaptable to local conditions. *Environment:* 1) Collaboration between professional associations and government sector important.
Matsudo et al 2003 (63)	Community in Sao Paulo.	Agita Sao Paulo promoted CDC recommendations of performing at least 30 minutes of moderate-intensity physical activity per day, on one or more sessions each day on most days of the week. Three specific target groups: students, workers, and the elderly.	*Study type*: Evaluation to assess program impact, used various surveys to assess changes in the level of physical activity and participant knowledge. *Analysis:* Varied by intervention	*Engagement:* 1) Used extensive free media coverage	*Program design:* 1) Adopted the "two hats" approach, using either governmental or nongovernmental methodologies to promote physical activity.

Nelesone et al. 2006 (69)	One hospital and seven island clinics in Tuvalu (Pacific country).	Outbreak surveillance concept developed in South Africa, adapted and transferred to a Pacific island nation (decentralized model with limited number of syndromes).	*Study type:* Evaluation of disease surveillance system: zero reporting progress, completeness of reporting; structured system review and in-depth interviews. *Analysis:* not addressed	*Engagement:* 1) A greater commitment of resources for control strategies and infrastructure improvements after outbreak; 2) No formal feedback to clinic staff on their performance.	*Accountability/leadership:* 1) Need for ongoing monitoring and responsive adaptation to feedback from surveillance agents based in the periphery of the health system.
Plamondon et al. 2008 (78)	Nicaragua's Global Fund project (GFP)	Tuberculosis component of Nicaragua's Global Fund project (GFP). Focus on training volunteer health workers and establishing TB Clubs to highlight potential for and threats to building sustainable program capacity. 19 participants included persons affected by TB, brigadistas, front-line health workers, regional and national staff, and advisors. Focus groups with 6 additional participants.	*Study type:* Ethnology-based case study design. Explores local experiences from the time of proposal development through to performance-based evaluation. Data collection included: review of historical documents, secondary data analysis, participant observation, semi-structured and in-depth interviews, and focus groups. *Analysis:* iterative process	*Engagement:* 1) Enhancing capacity among health workers, 2) Providing funding was counterproductive because it established an unsustainable precedent of incentives for participation, 3) lack of worker acknowledgement a barrier to program sustainment, and 4) Improved communication at local, regional and national levels	*Accountability/leadership:* 1) Dependency on local leadership without investment in leadership development was problematic, 2) Lack of prioritization of TB control program within broader public health system, and 3) Gaps in evaluation in area of quality. *Program design:* 1) Lack of regular follow-up training or education materials.
Zvavamwe et al 2008 (106)	40 nurses involved in providing treatment and care	Community-based TB program.	*Study type:* Descriptive quantitative study	*Engagement:* 1) Use of incentives for TB patient & staff	*Accountability/leadership:* 1) Experienced poor supervision of staff and inadequate record keeping.

	of TB patients in the Omaheke region of Namibia .		using structured interviews. *Analysis:* descriptive statistics	participation, and 2) Established community based structures to support TB work.	
Dick et al. 2007 (29)	Pilot project on 21 farms in Boland Health District, Western Cape Province, South Africa, during 1993-95. Randomized trial sample size of 211 was achieved (106 intervention and 105 control group) that commenced TB treatment (2000 to 2001).	Farm dwellers were assisted in selecting suitable peers to be trained as Lay Health Workers (LHWs), 92% were female. Phase 1: Preparation: Informing each farming community of study, TB and selection process for LHWs, done before randomization. Phase 2: Training the LHWs with 5 one-week modules offered during 5 month period on a decentralized basis in farming district, experiential learning approach was used, flexible to respond to specific needs of each learner, each group 6-10 participants. Phase 3: support of LHWs with monthly visits during implementation. Researchers fed study findings to participants for validation, facilitated by development of posters	*Study type:* Series of discrete studies including 1) un-blinded cluster randomized trial, 2) formal cost study (control vs. intervention), and 3) in-depth interviewing, focus groups, field notes and participant observation to describe perceptions of key stakeholders. *Analysis:* Statistical comparison of groups, nonparametric testing, and qualitative methodology (i.e. content analysis and coding).	*Engagement*: 1) Perception developed that money and time were saved through program, 2) Changed LHW own behavior, became "role model in community," and 3) Led to decrease dependence on external sources including farm management and health services.	*Program design:* 1) LHWs were trained in other useful skills to deal with health issues.

		displayed in district health facilities, and brochure for policymakers and community members.			
Ryman et al. 2008 (83)	Review of the published and gray literature. Initial inclusion criteria applied to 60 papers. Standardized quality assessment of methodology of 25 papers.	Studies and projects conducted to improve routine immunization programs among humans in low- or middle- income countries.	*Study type:* Systematic literature review: online databases search using 42 terms for papers in English, French or Spanish from 1975- 2004. Gray literature was searched on 35 websites. *Analysis:* Following abstract review, papers classified in 3 methodological groups and rated based on a standardized assessment.	*Engagement:* 1) Included food incentives for participation, 2) Improved quality of health facility practices can improve immunization rates, and 3) Used mass communication campaign/ information dissemination to increase demand for vaccination	*Program design:* 1) Focus on bringing immunizations closer to the community using non-health workers. *Accountability/leadership:* 1) Tools developed to assist community workers in tracking their home visits.

Appendix F: Summary of included studies related to the environment

Reference	Sample characteristics	Details of intervention	Study design and analysis	Important observations (primary)	Important observations (secondary)
Barat et al. 2006 (5)	4 countries: Brazil, Eritrea, India and Vietnam that successfully reduced malaria morbidity.	Brazil: 1989 Project for Control of Malaria in Amazon Basin (PCMAM); Eritrea: 1999 MOH Program for Control of HIV, Malaria, STDs and TB (HAMSET), India: Enhanced Malaria Control Project (EMCP); Vietnam: MOH focused on malaria as priority.	*Study type:* Cross-sectional; review of published and unpublished reports; interview of selected program and partner staff involved in design, implementation and/or supervision. *Analysis*: not addressed	*Environment:* 1) Capacity at national and sub-national levels (skilled technical staff at sub-national level), 2) Sufficient and flexible financing from government and partners, 3) Hands-on technical and programmatic support from partner agencies and 4) Decentralized control of resources.	*Program design:* 1) Includes data-driven decision making. *Accountability/leadership:* 1) Active leadership at all levels of government .
Creati et al. 2007 (22)	Southeast Sulawesi and Maluku in Indonesia where 97% of mothers gave birth at home. 839 mothers with children < 2 years old.	Healthy Mothers-Healthy Babies Project aims to integrate the administration of birth dose Hepatitis B vaccine into an expanded routine delivery care package provided by village midwives.	*Study type*: Evaluation study following 5 years of implementation. *Analysis*: descriptive	*Environment:* 1) Low coverage due to health system structure rather than a result of community practices or lack of community acceptance, 2) Mistrust of staff who are not normally part of program, 3) Reluctance on the part of immunization staff to allow vaccine outside of cold chain, and 4) Difficulties in reliably of supplying potent vaccine to community level due to limited transportation system.	*Program design:* 1) Training allowed better understanding of roles and empowered village midwives. *Accountability/leadership:* 1) Lack of clear delineation of responsibility between health care professionals.

Deen et al. 2003 (28)	Hospitals in developing countries meeting inclusion criteria. Postal survey sent to 36 recommended hospitals; 23 (63.8%) completed and returned. Pre-selection visits conducted in 4 hospitals in Africa and implementation started in 2 hospitals.	Pediatrician visits each study hospital 3 times, initially for 2 weeks, then for a week 3-6 months later and finally for another week at the end of study year. During each of the visits, the management of severely malnourished children is evaluated using a structured audit instrument.	*Study Type:* Initial feedback from extended field test of the WHO severe malnutrition guidelines. *Analysis*: not addressed	*Environment:* 1) Health worker attitude of helplessness or not being able to make a difference, 2) Lack of trust in guidelines, 3) Difficult to change established practices, and 4) Existing hospital policies, structure and politics impede actual practice.	*Engagement:* 1) Lack of interest or motivation of rotating junior doctors. *Accountability/leadership:* 1) Lack of awareness of shortcoming in management of severe malnutrition, and 2) Monitoring integrated into the routine. *Program design*: 1) Ability to formulate own protocol based on available resources, 2) Included technical documentation for each recommendation in the guideline, and 3) Structured as mandate to urge compliance.
Jacucci et al. 2006 (50)	New Hope hospital, with its functioning health information system, selected from group of hospitals in Eastern Cape, South Africa.	South Africa launched the creation of a unified health information system (HIS), to support data collection, aggregation and analysis at the district level. As part of implementation, hospitals were provided with new forms and registers for data collection, computers, and the HIS software. Training sessions were organized for the hospital staff.	*Study type*: Case study; Interviews with the hospital manager, the matron, the information officer and the nurses in the wards. Observed budget review meeting. *Analysis:* descriptive qualitative methods	*Environment:* 1) Availability and teamwork of skilled and competent people, and 2) Caring ethos around being an employee translated not only to care of patients but also to care of the environment.	*Program design:* 1) Administrative processes and forms supported simple data entry, 2) Staff developed their own solution (local adaptation of the standard) *Engagement:* 1) Layering of one information system over another created dependencies and forms of incentives for keeping the quality of data accurate. *Accountability/leadership:* Continuous-change process where the local organization reflected upon and proactively reinterpreted its own work processes.

Chaulagai et al. 2005 (18)	Health management information system (HMIS) in Malawi	*Objectives:* 5-year strategy for strengthening routine HMIS. Revised procedures manual tested in phases of 18 months starting with 3 health facilities and progressing to district and tertiary care facility, training for members from all districts, health information policy and indicators developed, routine monitoring included.	*Study type:* Descriptive study of a comprehensive HMIS introduced in the country in Jan 2002. *Analysis:* Not addressed	*Environment:* *1)* Desired teamwork not apparent, 2) Lack of management knowledge and skill, 3) Status (low) of personnel imbalanced to responsibilities, and 4) Operational pattern of health sector not changed.	*Accountability/leadership:* 1) Core set of indicators purposely limited in number, 2) Lack of accountability system to address poor performance. *Program design:* 1) Cascade "training of trainers" approach, 2 half-day practice-based training sessions better than 5 days training in classroom, 2) Program interpretation and dissemination to users packaged in a variety of ready-to-use formats. *Engagement:* 1) Focused on local analysis and use of information, and 2) Lack of financial incentives or reward system.
Gericke et al. 2005 (40)	Not addressed	*Objective*: To illustrate the use of a framework applied to condom social marketing programs for prevention of HIV/AIDS and other STDs, and DOTS strategy for tuberculosis control.	*Study type:* Development of a conceptual framework to categorize interventions according to degree of technical complexity. *Analysis:* not addressed	*Environment*: 1) Human resources insufficient, 2) Require National and local political support, 3) Pre-existing demand for program, 4) Need for regular supplies, equipment (high technology, infrastructure, different types, maintenance), and 5) Communication and transport infrastructure important.	*Accountability/leadership:* 1) Regulation and enforcement need for monitoring, 2) Need for training and supervision. *Program design:* 1) Need for training and supervision, 2) Standardization and simplification of procedures allows services to be provided by less skilled staff. *Engagement:* 1) Quality and quantity of non-financial incentives important, 2) Communication is important.

Kamadjeu et al. 2005 (54)	An original cohort of 14 providers (10 MDs and 4 nurses) from urban primary health care (PHC) practice in Cameroon.	A locally designed EHR system (MEDCAB) was developed based on the International Classification for Primary Care (ICPC). System consists of several user interfaces with multiple functionalities. A 3-day training session was organized for prospective users.	*Study type:* Cross-sectional. Several data collection strategies identified using subjectivist approaches, but focused mostly on direct observations and interviews. *Analysis:* Qualitative methods	*Environment:* 1) Lower priority given to project when management changed, 2) Limited attention from funders and policy makers, 3) High turnover of personnel, 4) Competition for primary health care data with actual emergencies, and 5) Limited computers and resources available.	*Program design:* 1) Insufficient training for EHR, 2) System should be designed to fit the medical environment, 3) Decrease in coding time realized after 4 months. *Accountability/leadership:* 1) Experienced leadership challenges. *Engagement:* 1) Increase in users' self-esteem and positive image of the facility in the community important, and 2) Activity reports and statistics useful.
Williams et al. 2004 (103)	Countries selected based on availability of descriptive data; included Tanzania, South Africa, Kenya, Peru and Malawi.	National Antimalarial treatment policy implemented in country.	*Study type:* Case studies summarized findings from various malaria treatment policy studies. Included review of historical documents in Malawi, individual and focus groups interviews, review of historical documents, and participatory methods (such as time lines) in other identified countries. *Analysis:* not addressed	*Environment:* 1) Broad lack of trust in intervention, 2) Current prescribing practices differed from policy (lack of compliance with regimes), 3) Political changes affected government stability and support, and 4) Felt competition from other national priorities.	*Engagement:* 1) Implementation plan included investment in health infrastructure and personnel, 2) Identification of individuals to affect and initiate change (gate-keepers), and 3) Presented arguments for change in concert with support from "credible" partners (international partners). *Accountability/leadership:* 1) Minimal guidance on how to determine "success" which fueled insufficient funding for monitoring/evaluation. *Program design:* 1) System designed to use emerging lessons.
Cutts et al. 1990 (26)	Urban and rural areas of	Conduction of door-to-door canvassing by volunteers of	*Study type:* Coverage surveys conducted in	*Environment:* *1)* Extensive continuing	*Accountability/leadership:* *1)* Expression of high level interest

	Mozambique: Beira, Tete, Quelimane, and Inhambane.	grassroots organizations to increase attendance to EPI (Extended Programme on Immunization).	1987 in provincial capitals and in rural and urban areas using WHO EPI cluster sampling method. Community representative was interviewed in each cluster before beginning the household visits. A detailed study of the full EPI costs and of the mobilizations cost.	donor support, 2) Political support, 3) Contribution of voluntary labor, 4) Resources were unavailable, power cuts, 5) Expectation of long waits, competing demands on time for users, 6) Health services support, improve patient flow in health centers.	and the encouragement to adopt ambitious goals placed pressure and resulted in uncritical adoption of strategies. *Engagement:* 1) Health staff established regular contacts with community, 2) Communities shared responsibility for implementation. *Program design:* 1) Refresher training included in design.

Appendix G: List of consensus workshop participants

Name	Position	Organization
Robert Fagan, BS	System Analyst at the Global Public Health Informatics Program	Centers for Disease Control and Prevention
Henry Rolka, RN, MPS, MS	Associate Director for Information Exchange	Centers for Disease Control and Prevention
David Blazes, MD, MPH	Chief, GEIS Operations Division	Armed Forces Health Surveillance Center
Jennifer Cockrill, MS, MPH	Infectious Disease Epidemiologist in the Division of GEIS Operations	Armed Forces Health Surveillance Center
Joel Gaydos, MD, MPH	Science Advisor	Armed Forces Health Surveillance Center
Julie Pavlin, MD, PhD, MPH	Deputy Director	Armed Forces Health Surveillance Center
Christopher Perdue, MD, MPH	Epidemiologist, Health Surveillance in the Division of GEIS Operations	Armed Forces Health Surveillance Center
Jacqueline Coberly, MHS, PhD	Senior Epidemiologist, ESSENCE Group	Applied Physics Laboratory-Johns Hopkins University
Sheri Lewis, MPH	Global Disease Surveillance Program Manager	Applied Physics Laboratory-Johns Hopkins University
Richard Wojcik, MS	Lead Software Engineer for the ESSENCE Project	Applied Physics Laboratory-Johns Hopkins University
Matthew Johns, MPH	Branch Chief, International Partnerships	US Department of Health and Human Services
Patrick Kelley, MD, DrPH	Director, Board on Global Health	Institute of Medicine
Ronald Gimbel, PhD	Assistant Professor, Biomedical Informatics Department	Uniformed Services University
Cesar Munayco, MD, MSc, MPH	DrPH student	Uniformed Services University
Cecilia Mundaca, MD, MPH	DrPH candidate	Uniformed Services University

Appendix H: Interview Introduction and Sample Interview Guide

Interview template introduction

Hello. My name is Cecilia Mundaca. Thank you for meeting with me today. I am a graduate student at the Uniformed Services University in Bethesda, Maryland. I am here today to learn about your experience with the implementation process of your electronic disease surveillance system.

I am doing this as part of my dissertation work, which aims to build a framework to understand the implementation of electronic disease surveillance systems in Peru. This is not an evaluation of your system nor is it an attempt to access your disease data. I am only interested in learning and understanding your experience related to implementation of disease surveillance systems and your ideas about the lessons you have learned from such an experience.

I will be asking you some questions and taking notes. With your permission, I would like to audio record this conversation since I don't want to miss or misinterpret any information you share with me. Our conversation and this recording will be confidential and will be destroyed after I finish my work. Please be sure you will not be identified with any information you share nor will your name be mentioned in any publications or reports that result from this study. Do I have your permission to record?

Do you have any questions before we start?

Interview Guide Template

Introduction (See template)

Questions:

Q1. What were some of the reasons a decision was made to implement this surveillance system?

Q2. What factors/stakeholders helped in this process to get started?

Probes:

- Political environment
- Funding/external support
- Existing infrastructure
- Human resources

Q3. What challenges did you face in implementing the system?

Q4. What factors helped this system work?

Probes:

- Political environment
- Funding/external support
- Existing infrastructure
- Human resources
- System design: training, tool design, program flexibility
- Monitoring and evaluation/supervision
- Accountability policies
- Stakeholder involvement
    - What stakeholders were important or critical in implementing the system?
- Communication strategies

Q5. How do you view this system in terms of success?

- How do you define success?

Q6. How long did it take for the system to become fully functional?

- Can you distinguish any phases of this process?

Q7. Are there any other successes, challenges or comments regarding your experience with the implementation of an electronic surveillance system you would like to share with me?

Q8. May I follow with you if I have further questions?

Interview notes template

Interview #: _____

Date: _____
Start time: _____
End time: _____

Audio-recorded? Y/N

Audio file number: ____

Notes

Observations

Follow up actions/data sources identified

Notes for review of main points

Appendix I: Coding process example

Raw data	Initial coding	Focused coding	Theoretical coding
Q. What are the elements needed for a successful implementation?			
I would definitely add an adequate legal framework. When we implemented the system in Ecuador in 25 sites, we did our part, train, supervise, but the Ecuadorian military always needed a legislation to support the system. That was never possible to obtain, so the system stopped being used…	Having a legal framework is key for these systems = "Legislation" System with no legislation was not sustainable = "Sustainability"	"Legislation as a key element" Having a legal framework is key for sustainability, and requires political will	"Sustainability requires detailed legislation of the process of implementation in place"
Q. Why was legislation not obtained?			
To obtain that legislation, they needed an international agreement among organization, and there was not enough will from the high leadership in Ecuador to have this go through, it is a long and tedious process…	Political will is needed to put in place legislation = "Political will"	"Detailed legislation" A description of processes and resources is needed in the legislation	
Q. What is an adequate legal framework?			
Legislation that supports the implementation process and a directive that describes all the activities and resources required to put this in place and maintain it… This directive has to be disseminated so all the surveillance staff knows what is the purpose of this system	Legislation should include all the resources and processes required for the system to be implemented and continue functioning = "Processes included in legislation"		

Appendix J: Results of Grey Literature review

Reference	Country/ External support	System/Tool	Study design and analysis	Factors observed to contribute	Challenges and needs
Curioso, W. H., B. Karras, et al. (2005). "Design and Implementation of Cell-PREVEN: A Real-Time Surveillance System for Adverse Events Using Cell Phones in Peru." AMIA Symposium Proceedings: 176-179.	Country: Peru External support: Imperial College, London University of Washington, Seattle	System: Cell-preven (pilot project, 3 cities) Reporting of adverse events to metronidazole used as treatment for vaginosis Tool developed on: mobile phones and website	Report of surveillance outputs: Sep-Dec 2004	Use a low-tech system to create a sophisticated solution. Partnership is key to overcome technology barriers. Training is one of the key factors in the success of the project.	
Domeika, M., G. Kligys, et al. (2009). "Implementation of a national electronic reporting system in Lithuania " Eurosurveillance 14(13): 1-6.	Country: Lithuania External support: Swedish Health Care Community	System: ULISAS Reporting of 76 communicable diseases(All 10 counties) Tool developed on: Off-line computer software	Report of structure and implementation process: 2000-2007	Partnership with external donor was of vital importance (communication and funding). Political engagement and government financial support facilitated by Lithuanian legislation. Offline tool was selected to meet resources capacity (no Internet access at all sites). Bottom up policy with process starting at county level. Staff at counties was motivated to change to new system. Resources already in place Pilot project before involving the national level,	Need for integration to other systems Need for better analysis tools
Ear, S. (2012). "Emerging Infectious Disease Surveillance in Southeast	Countries: Cambodia and Indonesia	Indonesia: System: EWORS (Early Warning Outbreak	Semi-structured interviews of stakeholders	System is nationally owned	Limited skilled human resources. Poor staff and human

Asia: Cambodia, Indonesia, and the US Naval Area Medical Research Unit 2." Asian Security 8(2): 164-187.	External donor: US Naval Medical Research Unit 2	Recognition System, 11 hospital, 8 provinces) Tool developed: Offline software on computer to transmit over the Internet			resources management. Different priorities between donors and government. Poor host-donor relationships. Difficulties incentivizing local-level reporting. Limited government resources and financial commitment. Awareness of local political, economic and cultural issues.
Franco, L., J. Setzer, et al. (2006). Improving Performance of IDSR at District and Facility Levels: Experiences in Tanzania and Ghana in Making IDSR Operational, PHRplus	Countries: Tanzania and Ghana External support: *PHRPlus*	System: IDSR (Integrated Disease Surveillance and Response) Tanzania(12 provinces); Ghana(3 regions) Tool: Computer software Installation and use of radio calls Individual cell phones to send text messages	Description of efforts of *PHRplus* to improve performance of IDSR	Supervision and follow-up are critical for performance improvement. Addressing technical determinants: - Creating guidelines that define norms and forms - Clarifying standards for data analysis - Creating technical capacity to collect, manage analyze and communicate data Addressing Organizational determinants: - Clarifying roles and responsibilities - Budgeting at local levels - Outlining clear procedures for tasks - Mechanisms for involving other actors - Resolving communication/reporting	Advocacy based on data from district and facility staff. Engagement of stakeholders at all levels. Government commitment to provide resources, accountability and communication mechanisms. Understand the links between the surveillance strategy and the country political context.

				constraints - Strengthening supervision Addressing workforce determinants: - Bottom-up capacity building - Creating training capacity - Use of job aids for standard case definitions, data interpretation, etc.	
Huaman, M. A., R. V. Araujo-Castillo, et al. (2009). "Impact of two interventions on timeliness and data quality of an electronic disease surveillance system in a resource limited setting (Peru): a prospective evaluation." BMC Med Inform Decis Mak 9: 16.	Country: Peru External support: NMRCD (Naval Medical Research Center Detachment)	System: Alerta DISAMAR Tool: Internet-based platform with phone (IVR) or computer based reporting	12 week prospective evaluation (40 reporting units) 3 groups randomly assigned (phone, visit or control group)	Regular phone call reminders enhanced timeliness of report Supervision did not improve timeliness. Supervision visits improved data quality in the clinic sites vs. ships.	
Jefferson, H., B. Dupuy, et al. (2008). "Evaluation of a syndromic surveillance for the early detection of outbreaks among military personnel in a tropical country." Journal of Public Health 30(4): 375-383.	Country: French Guiana External support: French Armed Forces	System: syndromic surveillance system 2SE FAG (Surveillance Spatiale des epidemies au Sein des Forces Armees en Guyane) Tool: a computer in a permanent medical unit or a PDA on a mission	Evaluation using CDC framework (qualitative and quantitative analysis)	The timeliness of the system was one of its major strong points. The system consistently detected febrile outbreaks.	Areas of acceptability needed to improve: - Time taken to use the system (need to simplify data input forms) - Actual use of the system by people who enter the data Introduction of a standardized protocol to respond to system alarms. Military specificities need to be integrated in the evaluation guidelines. Minimize the occurrence of hindering technical

					problems.
John, T. J., R. Samuel, et al. (1998). "Disease surveillance at district level: a model for developing countries." Lancet 352(9121): 58-61.	Country: India	System: NADHI (North Acorn District Health Information) 10 notifiable diseases (one district in the southern state of Tamil Nadu) 196 government and 426 private reporting centers Tool: All data were entered in a computer	Description of the implementation of the project	Single disease surveillance was unlikely to motivate private sector physicians Successful disease surveillance must combine: - Remove the fear of reporting on government sector staff - Obtain private sector participation Inexpensive system. Motivation of reporting staff was maintained by: - Periodic visits from the field staff - Occasional CME meetings - Supply of free vaccines	No reporting in rural health centers due to the fear of being blamed for not reaching vaccination targets. Not able to establish etiological diagnosis. There is no system of enforcement. In the absence of action or at least feedback, people lose interest.
Kant, L. and S. K. Krishnan (2010). "Information and communication technology in disease surveillance, India: a case study." BMC Public Health 10 Suppl 1: S11.	Country: India External support: World Bank (funding) CDC and WHO (technical assistance)	System: IDSP (Integrated Disease Surveillance Project, 85% of all districts) Tool: Single stop web portal (Broadband and satellite network) 24/7 call center	Description of the surveillance system	Communication network enhanced and frequently used. Ongoing training for reporting staff and data managers, use of communication network to provide e-learning experience, appropriate e-modules developed. Enhanced networking of infectious disease hospitals. Quality and timelines of reporting improved.	Encourage private sector reporting. Strengthening skills for data use and analysis at all levels. Enhance integration with other national programs. Incorporate mobile, text, voice, email and fax technology to the portal.
Kebede, S., J. B. Gatabazi, et al. (2011). "Strengthening systems for communicable disease surveillance: creating a laboratory network in Rwanda." Health Res	Country: Rwanda External support: WHO, CDC, Columbia University and	System: National Public Health Laboratory System (34 district hospitals, 385 health centers)	Evaluation of the system (review of documents and interviews with stakeholders)	Structured governing framework for public health surveillance. Political commitment to promote leadership for stronger laboratory capacity. Defined roles and	Weaknesses in the general infrastructure. Insufficient number of skilled human resources. Budgetary constraints. Shortage of vehicles, equipment, supplies and

Policy Syst 9: 27.	USAID	Tool: computer system		responsibilities for each level. Coordinated approaches between technical and funding partners. Collaboration with external laboratories. Use of performance results in advocacy with national stakeholders. Advocacy, provision of equipment, training and research (partner resources).	reagents. Use of multiple forms from a variety of implementing partners resulting in duplication of efforts and resources. Geographic barriers Erratic supply of electricity affects computer and Internet access. Defined communication channels between the levels of the health system.
Lukwago, L., M. Nanyunja, et al. (2012). "The implementation of Integrated Disease Surveillance and Response in Uganda: a review of progress and challenges between 2001 and 2007." Health Policy and Planning 28(1): 30-40.	Country: Uganda External support: WHO AFRO, CDC, USAID	System: IDSR (Integrated Disease Surveillance and Response) Tool: Computer based	Evaluation at the national, district and health facility levels using CDC and WHO framework from 2001-2007 (multi-stage stratified sampling)	IDSR improved surveillance and response efforts (improvement in completeness and timeliness of reporting, gradual increase in outbreaks recording, greater use of data collected). Multiple communication channels: radio call, telephone, fax and Internet; between district and national level. Increased technical support at the startup of IDSR. Better availability of equipment, reagents and supplies. Weekly publication served as advocacy and accountability tool. IDSR training support and the existence of surveillance management information system focal persons supported by WHO.	Decreased budgetary support from government. Drop of timeliness of reporting probably due to new districts with inadequate capacity. Failure to recruit trained personnel due to limited funding. Low capacity to confirm priority diseases. Rapid increase in the number of health districts in the strategy.

				Link between high political and financial commitment and ISDR performance.	
PHRplus and N. I. f. M. Research (2006). Follow-up Monitoring and Evaluation of Integrated Disease Surveillance and Response in Tanzania, Funding by USAID.	Country: Tanzania External support: USAID, Partners for Health Reform plus Project (PHR plus)	System: ISDR (Integrated Disease Surveillance and Response) 13 notifiable diseases Tool: Computerized system	Follow-up evaluation (Jan-Mar 2005) in 12 districts from 8 regions. Total of 109 health facilities visited. Sampling framework	Timeliness and completeness of reports increased substantially. Use of data to plan and monitor. Monitoring and evaluation and support required. Strong coordination and communication with partners and stakeholders. Intense training and development of tools and job aids. National and regional level commitment. Motivation: - Workers supported and valued by colleagues and supervisors - Workers who feel they are making a contribution - Workers supported in solving work-related problems	Need to improve use of case investigation forms. Not regular conduction of analysis at the facility and district level. Follow up on training on outbreak preparedness. Improve feedback to all levels of the system. Ongoing support over a longer period of time for health workers. Lack of resources and funding. Limited time to do surveillance tasks. Competing priorities at the health facility level.
PHRplus (2006). Georgia Immunization MIS and Disease Surveillance Reforms: Achievements, Lessons Learned and Future Directions, Funded by USAI	Country: Georgia External support: PHR plus	System: Infectious Disease Surveillance Tool: software application	Description of efforts to enhance surveillance system (IDS reforms in Imereti region 2004-2005)	Guidelines for health care providers. Job aids for district level. Laboratory reference manual. District level training. Continuous supervision and support. Monitoring and evaluation. Developing a network of laboratories. Improving human resource management.	Utilization of data remained weak. Inadequate public funding of surveillance activities. Lack of legal or administrative authority for management and governance issues. Inadequate financial and administrative motivators for reporting staff. Donors should demand

				Improvements need to reflect national high priorities. Appropriate organizational structure. Sufficient infrastructure. Financial structures. Routine program of continuous education covering surveillance topics. In a small country, disease surveillance funding should come from the central budget. Disease surveillance projects should take two years for development and testing and three years for adequate institutionalization.	governments share a portion of the costs which improves the chances for sustainability. Overall strategic vision prior to reforming system components. Adequate staffing with clearly defined roles. Finalize development of public health law. Advocacy measures help identify and clarify priorities. Integrate individual program specific software into a unified platform.
Rajatonirina, S., J. M. Heraud, et al. (2012). "Short message service sentinel surveillance of influenza-like illness in Madagascar, 2008-2012." Bull World Health Organ 90: 385-389.	Country: Madagascar External support: Institut Pasteur of Madagascar	System: Sentinel Surveillance system for Influenza like illness (34 sites) Tool: use of cell phones	Evaluation of the implementation process (2008-1011)	Advantage of suing syndromic data for timeliness in outbreak detection. Mobile phone technology proved to be a useful tool. Motivation of reporting staff: Provision of medical equipment Training opportunities (annual epidemiology workshop and annual meeting) Health district officers trained to train and supervise new staff.	Need to rely on strong communication systems, cost of maintaining this network needs to estimated. High staff turnover.
Robertson, C., K. Sawford, et al. (2010). "Mobile phone-based infectious disease surveillance system, Sri Lanka." Emerging infectious diseases 16(10): 1524-1531.	Country: Sri Lanka External support: Teasdale-Corti Global Health Partnership and the National	System: Infectious Disease Surveillance and Analysis System (IDSAS). Pilot project in 4 districts Tool: Mobile phone based	Description of the design and implementation	Technical considerations: Use of familiar technologies minimize training time Developing local expertise to ensure sustained technical and logistical support Financial considerations: Hardware available should be	Distinction between the IDSAS as a research project and the national reporting system.

	Sciences and Engineering Research Council of Canada			used Open source software should be selected Political considerations (most important factor): External financial support to cover initial investment required Support at all levels of the government at the early implementation phase In the design process: select outputs of the system and their value Ethical, societal, cultural: Build appropriate data security in the system Adoption requires user acceptance and new technical skills (time and experience)	
Singh, V., R. Madhusudan, et al. (2011). "An evaluation of mobile phone technology use for Integrated Disease Surveillance Project (IDSP) in Andhra Pradesh, India." ISDS Conference Abstracts.	Country: India (6 districts in Andhra Pradesh)	System: IDSP (Integrated Disease Surveillance Project) Tool: use of mobile phones	Evaluation of the system (probability proportion to size sampling strategy)	Use of mobile phone technology has the potential to enhance efficiency and effectiveness of the system.	Lack of clear directives for implementation. Lack of guidelines for usage. Lack of systematic training of workforce for using a system. Adequate resources.
Siswoyo, H., M. Permana, et al. (2008). "EWORS: using a syndromic-based surveillance tool for disease outbreak detection in Indonesia." BMC Proc 2(S3).	Country: Indonesia External support: Naval Medical Research Unit 2 (NAMRU 2)	System: EWORS (Early Warning Outbreak Response System) 29 signs and symptoms compatible with infectious diseases (9 hospitals)	Description of the functioning of the system	Human resources: hospital program manager, data entry clerk exclusively dedicated. Regular basis training of health care workers. Hospital directors' commitment. EWORS package.	High cost to continue the program. Difficulties in creating team work. Struggle to maintain commitment by participating hospitals.

		Tool: hospital-based network of computerized linkages		Finances. Computer networking. Technical aspects: special phone lines, dedicated computer, data collection forms. Data analysis results.	
Soto, G., R. V. Araujo-Castillo, et al. (2008). "Challenges in the implementation of an electronic surveillance system in a resource-limited setting: Alerta, in Peru." BMC Proc 2 Suppl 3: S4.	Country: Peru External support: Naval Medical Research Center Detachment (NMRCD)	System: Alerta (45 clinical diagnosis or syndromes), 88 navy sites and 120 army sites Tool: software access through any public phone or computer with Internet connectivity	Retrospective description of the challenges in the implementation	Use of resources already in place. Training before deployments and local replication of courses. VHF radio relay process that reports from remote areas. Paired surveillance sites with regional diagnostic laboratories and streamline process of sending samples to lab in the capital. Use of standardized templates and reporting via electronics means. Short average time to send a report. Standard analysis is automated to facilitate use of data. Continuous monitoring of the sites for timeliness and error rates allowed targeted training. Convincing stakeholders that their efforts are useful and valuable. Creating a surveillance culture by training. Fully dedicated technician to monitor the sites. Persistent and focused evaluation.	Issues with stakeholders: Limited epidemiological training Continuous movement of trained personnel Resources: Remote areas without access to phones and computers Lack of laboratory confirmation Processes: Reporting a large number of cases Low report on time rate, low data quality and low outbreak detection during expansion process Central hub: Data analysis takes long time to perform Expansion of new sites

Sow, I., W. Alemu, et al. (2010). "Trained District Health Personnel and The Performance of Integrated Disease Surveillance in the WHO African Region." East African Journal of Public Health 7(1): 16-19.	Country: 8 African countries External support: WHO, CDC	System: IDSR (Integrated Disease Surveillance and Response) 19 priority diseases	Secondary analysis of the evaluation reports to asses training approaches	Training of district health personnel contributed to the improvement in timeliness and completeness of reporting. Sustained commitment of health facility personnel. Sustainable district supportive supervision and feedback may sustain the performance. Reliable communication Availability of simplified reporting tools. Availability of sustained and integrated funding of training activities.	Reaching the health facility level in 3-4 years after implementation. Single day-long training sessions are inadequate. Lack of simplified surveillance forms impact the performance.
Wamala, J. F., C. Okot, et al. (2010). "Assessment of core capacities for the International Health Regulations (IHR[2005])--Uganda, 2009." BMC Public Health 10 Suppl 1: S9.	Country: Uganda External support: WHO	System: IDSR (Integrated Disease Surveillance and Response) Tool: SMS, telephone, email and radio call	Descriptive cross-sectional assessment of IHR within IDSR (convenience sample)		Revision of national legislation facilitated full implementation. Partnerships and inter-sectoral collaboration. Advocacy for IHR needs to be prioritized to ensure commitment of resources. Revised tools and guidelines should be disseminated to all stakeholders. Build human capacity. Development of a national preparedness plan.
Weber, I. B. (2007). Evaluation of the Notifiable Disease Surveillance System in Gauteng Province, South Africa, University of Pretoria. Master of	Country: South Africa	System: Notifiable disease surveillance system (Gauteng Province) Tool: electronic data submission	Evaluation study (qualitative and quantitative analysis) Jan-Jun 2006	Maintain communication and feedback on a regular basis. Evaluation of the system at regular intervals. Prioritize list of diseases under surveillance. Planning for human resources.	Low level of compliance due to time constraints and lack of motivation. Limited knowledge of the notification status of selected medical conditions.

Medicine in Community Health: 106.				Training and support of reports in both public and private sector. Incorporation of notifiable disease reporting in CME programs. Regular bidirectional communication should be maintained between public and private sectors. Dissemination of results and interpretation of notification data.	Lack of feedback between the public and private sectors. Lack of standardized procedures of reporting. The quality of notification. No dedicated surveillance officer at the provincial unit. High workload on a limited number of staff.
WHO (2003) Implementing integrated disease surveillance and response - Successes, challenges and lessons learned: the Uganda experience (ISDR). Weekly epidemiological record 27, 229-240	Country: Uganda External support: WHO, CDC, USAID, UN	System: IDSR (Integrated Disease Surveillance and Response) Tool: electronic communication between central level and districts, and radio contact.	Documentation of the implementation	Strong support from the political leadership. The MOH provides continuous feedback to all levels on ISDR. Development of joint surveillance work plans that articulate roles and responsibilities of each stakeholder. Creation of a budget-line for surveillance. The effectiveness of outbreak control through the system increased political commitment. National IDSR committee created to coordinate surveillance activities. Team spirit and trust grew among stakeholders. Standard case definitions and actions thresholds for priority diseases were distributed to all facilities. Award prizes to districts with	Need to improve feedback from district to lower elves and motivate health workers. The private sector has not been fully involved (framework needs to be developed). Data management and analysis at lower levels. Critical need for training in statistical and mapping software programs. Build district capacity in computerized data management systems. Standardization of surveillance tools and software. Networking between laboratory and epidemiological surveillance. Need to strengthen

				good performance. Use of surveillance information to formulate policy. Weekly newsletter is a tool for monitoring performance by politicians, resulting in increased commitment. Simplified forms. Supervision relevant to the work of reporting staff. Creation of laboratory networks, role of lab personnel well defined. Use of outbreak awareness to increase commitment. WHO's role was critical in technically supporting the process. Advocacy and networking are crucial. Strong donor support.	laboratory capacity. Create a mass of skilled human resources.
WHO (2005). Global consultation on strengthening national capacities for surveillance and control of communicable diseases. Geneva, World Health Organization.	Countries: Uganda 1, India2, Romania3, Lebanon4, Cambodia5, Ghana andTanzania6, Brazil7	National disease surveillance systems Tool: computerized data reporting system7	3-day global workshop on strengthening national capacities for surveillance and control of communicable diseases	High level commitment 1,3,4 (Development of National Health Sector Strategic Plan6, focused district plans and resources2; national committee2)1 Regular feedback1,4 Local capacity building1,4 Networking4,7 and partnership3 (laboratory)1,7 Training1,6,7, training manuals6 Behavioral change was critical for application of skills learned6 Clearly communicate expectations of performance6	Analysis at lower levels Support from all stakeholders1 Improve the quality of data and use for public action1 Filling gaps in coordination3 Establishing/updating a legal framework3,4,5 Lack of accreditation and laboratory quality assurance3 Raise awareness of health providers4 Maximize use of information technology4

				Appropriate job aids, tools, guidelines6 Social mobilization1 Monitoring and evaluation1 Use of thresholds1,4 Legal framework4	Producing regular updates5 Improving data management at central level5 Update of list of diseases5
WHO, CDC, et al. (2003). The Implementation of Integrated Disease Surveillance and Response in the African and Eastern Mediterranean Regions.	Countries: Burkina Faso, Ethiopia, Ghana, Mali, Uganda, Southern Soudan Nov-Dec 2002 External donor: WHO	System: IDSR (Integrated Disease Surveillance and Responses) and EWARN (Early Warning and Response Network)	Documentation of the implementation of these systems (mainly qualitative data)	Sensitization efforts on all stakeholders (direct communication with health workers with relevant information). Adaptation of guidelines and tools. Training sessions. Regularly supervise the trained personnel. Informal opportunities for on-site training. Evaluate the performance of the system. Meetings of surveillance and lab personnel. Use of radio network is effective to bridge the communication gap. Coordination with other programs. Directive at the national level.	Bring guidelines to the peripheral levels. Continuous sensitization on basic principles of surveillance and the use of adapted tools at all levels. Limited access to remote communities due to poor transportation network and absence of phone communication. Integration should be at the donor level, national programs and regional offices. Improve technical level coordination and integration. Strengthen links between central, regional and district labs.
Wuhib, T., T. L. Chorba, et al. (2002). "Assessment of the infectious diseases surveillance system of the Republic of Armenia: an example of surveillance in the Republics of the former Soviet Union."	Country: Republic of Armenia External support USAID, CDC	System: Armenian Infectious Disease Surveillance System (AIDSS) 64 infectious diseases	Evaluation of the system using CDC framework (qualitative methods)	Eliminate punitive consequences for reporting. Prioritize diseases under surveillance based on public health importance. Categorized diseases into a tiered case definition. Simple reporting procedures	List of diseases under surveillance had not been prioritized. No tiered case definitions (confirmed, probable, suspected). Epidemiologist did not use analytic methods to assess

BMC Public Health 2: 3.				and forms. Provided ongoing training in analytic epidemiology. Base interventions on epidemiologic evidence. Large numbers of health facilities and trained personnel. Separation of preventive from curative medicine. Provide feedback to all reporting sources and share information across programs.	risk factors for diseases. Little or no feedback provided to original reporting sources. Data collection process was complex (labor intensive). Constrained resources. Limited lab confirmation No outbreak reporting due to fear to punishment.

Appendix K: Workshop agenda

Expert Consensus Workshop on Electronic Disease Surveillance Systems Implementation in Developing Countries

AGENDA

Wednesday February 22nd, 2012

08:00 – 08:15	Welcome and Opening Remarks	Dr. Julie Pavlin
08:15 – 08:30	Introduction of participants	
08:30 – 09:15	Presentation of literature results Objectives of the Workshop	Dr. Cecilia Mundaca
09:15 – 10:00	Overview of common vision General discussion: Electronic disease surveillance definition Group assignments	Dr. Patrick Kelley
10:00 – 10:15	Break	
10:15 –12:00	Session 1: Group discussion Group 1: Phases or stages of implementation of an electronic disease surveillance system in developing countries (Metrics) Group 2: Factors related to successful implementation of electronic disease surveillance systems in developing countries	Group 1: Dr. Jacqueline Coberly Dr. Ron Gimbel Group 2: Sheri Lewis Dr. Julie Pavlin
12:00 – 13:30	Lunch Optional tour to AFHSC facilities	Dr. Joel Gaydos
13:30 – 14:00	Inter-group sharing	Dr. Cecilia Mundaca Sheri Lewis Dr. Jacqueline Coberly
14:00 – 15:30	Session 2: Group discussion (continuation) Group 1 & Group 2	Group 1: Dr. Jacqueline Coberly Dr. Ron Gimbel Group 2: Sheri Lewis Dr. Julie Pavlin
15:30 – 16:30	Inter-group sharing End of workshop debriefing	Dr. Cecilia Mundaca Sheri Lewis Dr. Jacqueline Coberly

Appendix L: List of interviewees

Interview #	Organization	Stakeholder	# Interviewees Military(M)/ Civilian(C)
1	NAMRU-6	Technical assistance	C=2
2	Peruvian Navy	National surveillance team	M=1
3	Peruvian Army	National surveillance team	C=1
4	Peruvian Army	National surveillance team	C=1
5	MOH- NIH	National surveillance team	C=1
6	Peruvian Navy	National surveillance team	M=1
7	Voxiva	Technical assistance	C=1
8	MOH-DGE	National surveillance team	C=1
9	MOH-DGE	National surveillance team	C=1
10	MOH-NIH	National surveillance team	C=1
11	Peruvian Army	National surveillance team	C=1
12	NAMRU-6	Technical assistance	C=3
13	Peruvian Navy	National surveillance team	C=1 M=1
14	Peruvian Navy	Reporting staff	C=1 M=3
15	Peruvian Army	National surveillance team	C=1
16	Peruvian Navy	Reporting staff	M=5
17	Peruvian Army	Reporting staff	C=1
18	Peruvian Army	Reporting staff	C=1
19	Peruvian Navy	Reporting staff	C=1
20	MOH	Administrative level	C=1
21	Peruvian Army	National surveillance team	C=1
22	MOH	Reporting staff	C=1
23	MOH	Regional surveillance team	C=1

Appendix M: Glossary

- Purposeful sampling: Purposeful sampling focuses on selecting information-rich cases whose study will illuminate the questions under study. Purposeful sampling is sometimes called purposive or judgment sampling: "In judgment sampling, you decide the purpose you want informants (or communities) to serve, and you go out to find some (Bertrand 2000: 176). There are several different strategies for purposefully selecting information-rich cases. The logic of each strategy serves a particular purpose. Source: Patton M. Qualitative Research & Evaluation Methods 3 edition 2002.
  Note: Purposive sampling is not haphazard. Purposive sampling has a purpose; a subgroup has been identified and a rationale has been developed to study them. Convenience sampling is haphazard sampling. Data are collected from those who happen to be around. If we were to select the first four people coming into our agency for our sample, regardless of who they were, we would be drawing a convenience sample. There are reasons why these people come at this time and we do not know those reasons. Therefore, the sample is neither representative nor purposive. Source: Fitzpatrick J. Program Evaluation – Alternatives Approaches and Practical Guidelines. 4th edition 2011.

- Criterion sampling: The logic of criterion sampling is to review and study all cases that meet some predetermined criterion of importance, a strategy common in quality assurance efforts. Source: Patton M. Qualitative Research & Evaluation Methods. 3rd edition 2002.

- Snowball sampling: This is an approach for locating information-rich key informants or critical cases. The process begins by asking well-situated people: "Who knows a lot about _____? Whom should I talk to?" By asking a number of people who else to talk with, the snowball gets bigger and bigger as you accumulate new information-rich cases. Source: Patton M. Qualitative Research & Evaluation Methods 3rd edition 2002.

- Theoretical sampling: A method of data collection based on concepts/themes derived from data. The purpose of theoretical sampling is to collect data from places, people, and events that will maximize opportunities to develop concepts in terms of their properties and dimensions, uncover variations, and identify relationships between concepts. Source: Corbin J, Strauss A. Basics of Qualitative Research 3rd edition 2008.

- Intensity sampling: An intensity sample consists on information-rich cases that manifest the phenomenon of interested intensely (but not extremely). Extreme or deviant cases may be so unusual as to distort the manifestation of the phenomenon of interest. Using the logic of intensity sampling, one seeks excellent or rich examples of the phenomenon of interest, but not highly unusual cases. Source: Patton M. Qualitative Research & Evaluation Methods 3 edition 2002.

Appendix N: Informed Consent

WHY ARE YOU BEING INVITED TO TAKE PART IN THIS RESEARCH?

You are being invited to take part in a research study about implementation of electronic disease surveillance systems in Peru and the elements related to the success of this process. You are being asked to take part in this research due to your experience in such process. If you volunteer to take part in this study, you will be one of about 50 people to do so.

WHO IS DOING THE STUDY?

The person in charge of this study is Dr. Carmen Mundaca who is a doctoral student at the Uniformed Services University. This study is part of her dissertation work. This work will be supervised by her thesis advisory committee composed by six professors.

WHAT IS THE PURPOSE OF THIS STUDY?

The study seeks to understand how electronic diseases surveillance systems can be successfully implemented in Peru. Participants will be asked to share their experiences with successes and/or challenges when working on implementing such systems. We expect that the results of this study will potentially guide development of a framework for successful implementation of such systems in similar settings.

WHERE IS THE STUDY GOING TO TAKE PLACE AND HOW LONG WILL IT LAST?

The research will be conducted in Peru; potentially we will be interviewing participants from the Ministry of Health and Armed Forces. The total amount of time you will be asked to volunteer for this study is approximately 60 minutes. There might be follow-on activity for some participants if during the analysis the researcher needs to clarify concepts or obtain any additional information on what was shared during the interview. Participants will be asked during the interview if they agree to be contacted if needed. If the participant agrees, they will be contacted by email and a conversation will be arranged either by phone or Skype.

WHAT WILL YOU BE ASKED TO DO?

You will be asked six to seven open-ended questions. The interview is expected to last approximately 60 minutes. You will be provided with an introduction with the purpose of the study and if you agree, the interview will be audio-recorded and transcribed verbatim. Nothing you share will be linked directly to you. At the end of the interview, the researcher will provide you with a summary of the key points you shared during the interview to allow you the opportunity for any clarification or additional comments as necessary.

ARE THERE REASONS WHY YOU SHOULD NOT TAKE PART IN THIS STUDY?

You do not have to participate in this study if you choose not to. Your decision to participate or not to do it will not be shared with your superior.

WHAT ARE THE POSSIBLE RISKS AND DISCOMFORTS?

There are no anticipated risks associated with this study

WILL YOU BENEFIT FROM TAKING PART IN THIS STUDY?

There is no guarantee that you will get any benefit from taking part in this study. Your participation might provide useful information to shape the design of a framework to guide the implementation of electronic disease surveillance systems in similar settings.

DO YOU HAVE TO TAKE PART IN THE STUDY?

If you decide to take part in the study, it should be because you want to volunteer. You will not lose benefits or rights you would normally have if you choose not to participate. You can stop at any time during the study and still keep the benefits and rights you had before volunteering. If you decide not to take part in this study, your decision will not be shared with anyone.

IF YOU DON'T WANT TO TAKE PART IN THE STUDY, ARE THERE OTHER CHOICES?

If you do not want to be in the study, there are no other choices except not to take part in the study.

WHO WILL SEE THE INFORMATION THAT YOU GIVE?

We will keep private all research records that identify you to the extent possible. Your name will not be associated with the interview notes or the interview transcript. Your information will be combined with information from other participants taking part in the study. We are likely to publish the results of this study; however, you will not be identified in these written materials.

WILL YOU RECEIVE ANY REWARDS FOR TAKING PART IN THIS STUDY?

You will not receive any rewards or payment for taking part in the study.

WHAT IF YOU HAVE QUESTIONS, SUGGESTIONS, CONCERNS, OR COMPLAINTS?

Before you decide whether to accept this invitation to take part in the study, please ask any questions that might come to mind now. Later, if you have questions, suggestions, concerns, or complaints about the study, you can contact Dr. Carmen Mundaca at cmundaca@usuhs.mil (011) 511- 571-268-8366. If you have any questions about your rights as a volunteer in this research, contact the staff in the Office of Research at the USU.

WHAT ELSE DO YOU NEED TO KNOW?

USU is providing financial support and/or material for this study.

_____ _____

Signature of person agreeing to take part in the study Date

_____

Printed name of person agreeing to take part in the study

_____ _____

Name of [authorized] person obtaining informed consent Date

_____

Signature of Investigator

_____ _____

Name of witness to informed consent Date

_____

Signature of Witness

References

1. Albert J. 2007. Global patterns and country experiences with the formulation and implementaton of food-based dietary guidelines. *Nutrition and Metabolism* 51:2-7
2. Amaral J, Leite A, Cunha A. 2005. Impact of IMCI health worker training on routinely collected child health indicators in Northeast Brazil. *Health Policy Plan* 20:i42-i8
3. Ammenwerth E, Iller C, Mahler C. 2006. IT-adoption and the interaction of task, technology and individuals: a fit framework and a case study. *BMC Med Inform Decis Mak* 6:3
4. Asbroek AT, Delnoij DM, Niessen LW. 2006. Implementing global knowledge in local practice: a WHO lung initiative in Nepal. *Health Policy Plan* 20:290-301
5. Barat LM. 2006. Four Malaria Succes Stories: How malaria burden was succesfully reduced in Brazil, Eritrea, India and Vietnam. *Am J Trop Med Hyg* 74:12-6
6. Barat LM, Zucker JR, Barber AM, Parise ME, Paxton LA, et al. 1997. Malaria surveillance--United States, 1993. *MMWR CDC Surveill Summ* 46:27-47
7. Bean NH, Martin SM. 2001. Implementing a network for electronic surveillance reporting from public health reference laboratories: an international perspective. *Emerg Infect Dis* 7:773-9
8. Beatty A, Scott K, Tsai P. 2008. Achieving Sustainable Global Capacity for Surveillance and Response to Emerging Diseases of Zoonotic Origin, Institute of Medicine, Washington, DC
9. Bell DM. 2004. Public health interventions and SARS spread, 2003. *Emerg Infect Dis* 10:1900-6
10. Binder S, Levitt AM, Sacks JJ, Hughes JM. 1999. Emerging infectious diseases: public health issues for the 21st century. *Science* 284:1311-3
11. Brender J, Ammenwerth E, Nykanen P, Talmon J. 2006. Factors influencing success and failure of health informatics systems--a pilot Delphi study. *Methods Inf Med* 45:125-36
12. Brownstein JS, Freifeld CC. 2007. HealthMap: the development of automated real-time Internet surveillance for epidemic intelligence. *Euro Surveill* 12:E071129 5
13. Bryce J, Victoria C, Habicht J. 2005. Programmatic pathways to child survival: results of a multi-country evaluation of Integrated Management of Childhood Illness. *Health Policy Plan* 20:i5-i17
14. Calain P. 2007. From the field side of the binoculars: a different view on global public health surveillance. *Health Policy Plan* 22:13-20
15. CDC. 2001. Updated Guidelines for Evaluating Public Health Surveillance System, Centers for Disease Control and PRevention
16. CDC. 2005. Introduction to program evaluation for public health programs: A self-study guide, Centers for Disease Control and Prevention
17. CDC. 2011. *Public Health Surveillance Program Office.* http://www.cdc.gov/osels/ph_surveillance/

18. Chaulagai C, Moyo C, Moyo H. 2005. Design and implementation of a health management information system in Malawi: issues, innovations and results. *Health Policy Plan* 20:375-84
19. Chretien JP, Burkom HS, Sedyaningsih ER, Larasati RP, Lescano AG, et al. 2008. Syndromic surveillance: adapting innovations to developing settings. *PLoS Med* 5:e72
20. Chretien JP, Lewis SH. 2008. Electronic public health surveillance in developing settings: meeting summary. *BMC Proc* 2 Suppl 3:S1
21. Corbin J, Strauss A. 2008. *Basics of Qualitative Research*. United States of America: Sage Publications Inc.
22. Creati M, Saleh A, Ruff T. 2007. Implementing the birth dose of hepatitus B vaccine in rural Indonesia. *Vaccine* 25:5985-93
23. Curioso WH, Karras B, Campos P, Buendia C, Homes K, Kimball AM. 2005. Design and Implementation of Cell-PREVEN: A Real-Time Surveillance System for Adverse Events Using Cell Phones in Peru. *AMIA Symposium Proceedings*:176-9
24. Cutcliffe J. 2000. Methodological issues in grounded theory. *Journal of Advanced Nursing* 31:1476-84
25. Cutts F, Kortbeek S, Malalane R. 1988. Developing appropriate strategies for EPI: a case study from Mozambique. *Health Policy Plan* 3:291-301
26. Cutts F, Phillips M, Kortbeek S. 1990. Door-to-door canvassing for immunization program acceleration in Mozambique: achievement and costs. *International Journal of Health Services* 20:717-25
27. de Salazar L. 2005. Building capacity for risk factor surveillance in developing countries: a new approach. *Soz Praventivmed* 50 Suppl 1:S33-7
28. Deen J, weber M, Oazi S. 2003. An extended field test of the WHO severe malnutirion guidelines in hospitals in developing countries: preliminary observations. *Forum of Nutrition* 56:183-4
29. Dick L, Clarke M, van Zyl H. 2007. Primary health care nurses implement and evaluate a community outreach approach to health care in the South African agricultural sector. *international Nursing Review* 54:383-90
30. Domeika M, Kligys G, Ivanauskiene O, Mereckiene J. 2009. Implementation of a national electronic reporting system in Lithuania *Eurosurveillance* 14:1-6
31. EANMAT. 2001. Monitoring antimalarial drug resistence within national malaria control programmes: the EANMAT experience. *Trop Med Int Health* 6:891-8
32. Ear S. 2012. Emerging Infectious Disease Surveillance in Southeast Asia: Cambodia, Indonesia, and the US Naval Area Medical Research Unit 2. *Asian Security* 8:164-87
33. Eaves Y. 2001. A synthesis technique for grounded theory data analysis. *Methodological Issues in Nursing Research* 35:654-63
34. Fauci AS. 2005. Emerging and reemerging infectious diseases: the perpetual challenge. *Acad Med* 80:1079-85
35. Flahault A, Vergu E, Boelle PY. 2009. Potential for a global dynamic of Influenza A (H1N1). *BMC Infect Dis* 9:129
36. Forster M. 2008. Electronic medical record systems, data quality and loss to follow-up: survey of antiretroviral therapy programmes in resource-limited settings

Bulletin of the World Health Organization 86:939-47
37. Forster M, Bailey C, Brinkhof M. 2008. Electronic medical record systems, data quality and loss to follow-up: survey of antiretroviral therapy programmes in resource-limited settings. *Bulletin of the World Health Organization* 86:939-47
38. Franco L, Setzer J, Banke K. 2006. Improving Performance of IDSR at Distric and Facility Levels: Experiences in Tanzania and Ghana in MAking IDSR Operational, PHRplus
39. Freedman LP, Graham WJ, Brazier E. 2007. Practical lessons from global safe motherhood initiatives: time for a new focus on implementation. *The Lancet* 370:1383-91
40. Gericke CA. 2005. Intervention complexity - a conceptual framework to inform priority-setting in health. *Bulletin of the World Health Organization* 83:285-93
41. Gordon AN, Hinson RE. 2007. Towards a sustainable framework for computer based health information systems (CHIS) for least developed countries (LDCs). *Int J Health Care Qual Assur* 20:532-44
42. Heath H, Cowley S. 2004. Developing a grounded theory approach: a comparison of Glaser and Strauss. *International Journal of Nursing Studies* 41:141-50
43. Heeks R. 2006. Health information systems: failure, success and improvisation. *Int J Med Inform* 75:125-37
44. Herbst K, Littlejohns P, Rawlinson J. 1999. Evaluating computerized health information systems: hardware, software and human ware: experiences from the Northern Providence, South Africa. *Journal of Public Health Medicine* 21:305-10
45. Heymann DL. 2006. SARS and emerging infectious diseases: a challenge to place global solidarity above national sovereignty. *Ann Acad Med Singapore* 35:350-3
46. Hotchkiss DR, Eisele TP, Djibuti M, Silvestre EA, Rukhadze N. 2006. Health system barriers to strengthening vaccine-preventable disease surveillance and response in the context of decentralization: evidence from Georgia. *BMC Public Health* 6:175
47. Huaman MA, Araujo-Castillo RV, Soto G, Neyra JM, Quispe JA, et al. 2009. Impact of two interventions on timeliness and data quality of an electronic disease surveillance system in a resource limited setting (Peru): a prospective evaluation. *BMC Med Inform Decis Mak* 9:16
48. Huicho L, Davila M, Gonzales F. 2005. Implementation of the Integrated Management of Childhood Illness strategy in Peru and its association with health indicators: an ecological analysis. *Health Policy Plan* 20:i32-i41
49. InstituteofMedicine, ForumonMicrobialThreats. 2007. *Global Infectious Disease Surveillance and Detection: Assessing the Challenges—Finding Solutions, Workshop Summary.*
50. Jacucci E, Shaw V, Braa J. 2006. Standardization of health information systems in South Africa: the challenge of local sustainability. *Information Technology for Development* 12:225-39
51. Jahan RA. 2000. Promoting health literacy: a case study in the prevention of diarrhoeal disease from Bangladesh. *Health Promotion International* 15:285-91
52. Jefferson H, Dupuy B, Clauder H, Texier G, Green A, et al. 2008. Evaluation of a syndromic surveillance for the early detection of outbreaks among military personnel in a tropical country. *Journal of Public Health* 30:375-83

53. John TJ, Samuel R, Balraj V, John R. 1998. Disease surveillance at district level: a model for developing countries. *Lancet* 352:58-61
54. Kamadjeu RM, Tapang EM, Moluh RN. 2005. Designing and implementing an electronic health record system in primary care practice in sub-Saharan Africa: a case study from Cameroon. *Informatics in Primary Care* 13:179-86
55. Kant L, Krishnan SK. 2010. Information and communication technology in disease surveillance, India: a case study. *BMC Public Health* 10 Suppl 1:S11
56. Kebede S, Gatabazi JB, Rugimbanya P, Mukankwiro T, Perry HN, et al. 2011. Strengthening systems for communicable disease surveillance: creating a laboratory network in Rwanda. *Health Res Policy Syst* 9:27
57. Khatri G, Frieden T. 2002. Rapid DOTS expansion in India. *Bulletin of the World Health Organization* 80:457-63
58. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gotzsche PC, et al. 2009. The PRISMA statment for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. *BMJ* 339
59. Lombardo J, Buckeridge D. 2007. *Disease Surveillance: A Public Health Informatics Approach.* Hoboken, New Jersey: John Wiley & Sons, Inc.
60. Lonroth K, Uplekar M, Arova V. 2004. Public-private mix for DOTS implementation: what makes it work? . *Bulletin of the World Health Organization* 82:580-6
61. Lukwago L, Nanyunja M, Ndayimirije N, Wamala JF, Malimbo M, et al. 2012. The implementation of Integrated Disease Surveillance and Response in Uganda: a review of progress and challenges between 2001 and 2007. *Health Policy and Planning* 28:30-40
62. Madueno Davila M. 2003. Estudio de oferta de los servicios de salud en el Peru y el analisis de brechas 2003-2020, Partners for Health Reformplus, Bethesda, MD
63. Matsudo SM, Matsudo VR, Araujo TL. 2003. The Agita Sao Paulo Program as a model for using physical activity to promote health. *Revista Panamericana de Salud Publica* 14:265-72
64. May L, Chretien JP, Pavlin JA. 2009. Beyond traditional surveillance: applying syndromic surveillance to developing settings--opportunities and challenges. *BMC Public Health* 9:242
65. McCann T, Clark E. 2003. Grounded theory in nursing research - Methodology. *Nurse Researcher* 11:7-18
66. McKenzie J, Neiger B, Smeltzer J. 2005. *Planning, Implementing and Evaluating Health Promotion Programs.* San Francisco, CA: Daryl Fox
67. Moher D, Liberati A, Tetzlaff J, Altman DG. 2009. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *BMJ* 339:332-9
68. Moore J. 2010. Classic grounded theory: a framework for contemporary application. *Nurse Researcher* 17:41-8
69. Nelesone T, Durrheim DN, Speare R. 2006. Strengthening sub-national communicable disease surveillance in a remote Pacific Island country by adapting a successful African outbreak surveillance model *Tropical Medicine and International Health* 11:17-21
70. Okubagzhi G, Singh S. 2002. Establishing an HIV/AIDS programme in developing countries: the Ethiopian experience. *AIDS* 16:1575-86

71. Paquet C, Coulombier D, Kaiser R, Ciotti M. 2006. Epidemic intelligence: a new framework for strengthening disease surveillance in Europe. *Euro Surveill* 11:212-4
72. Patton MQ. 2002. *Qualitative Research and Evaluation Methods*. United States of America: Sage Publications, Inc. 598 pp.
73. Paul-Ebhohimhen VA, Poobalan A, van Teijlingen ER. 2008. A systematic review of school-based sexual health interventions to prevent STI/HIV in sub-Saharan Africa. *BMC Public Health* 8:1-13
74. Pavlin JA, Mostashari F, Kortepeter MG, Hynes NA, Chotani RA, et al. 2003. Innovative surveillance methods for rapid detection of disease outbreaks and bioterrorism: results of an interagency workshop on health indicator surveillance. *Am J Public Health* 93:1230-5
75. Perry HN, McDonnell SM, Alemu W, Nsubuga P, Chungong S, et al. 2007. Planning an integrated disease surveillance and response system: a matrix of skills and activities. *BMC Med* 5:24
76. PHRplus. 2006. Georgia Immunization MIS and Disease Surveillance Reforms: Achievements, Lessons Learned and Future Directions, Funded by USAID
77. PHRplus, Research NIfM. 2006. Follow-up Monitoring and Evaluation of Integrated Disease Surveillance and Response in Tanzania, Funding by USAID
78. Plamondon K, Hanson L, Labonte R, Abonyi S. 2008. The global fund and tuberculosis in Nicaragua. . *Canadian Journal of Public Health* 99:355-8
79. Rahimi B, Vimarlund V. 2007. Methods to evaluate health information systems in healthcare settings: a literature review. *J Med Syst* 31:397-432
80. Rajatonirina S, Heraud JM, Randrianasolo L, Orelle A, Richard V. 2012. Short message service sentinel surveillance of influenza-like illness in Madagascar, 2008-2012. *Bull World Health Organ* 90:385-9
81. Robertson C, Sawford K, Daniel SL, Nelson TA, Stephen C. 2010. Mobile phone-based infectious disease surveillance system, Sri Lanka. *Emerging infectious diseases* 16:1524-31
82. Rodier G, Hardiman M, Plotkin B, Ganter B. 2006. Implementing the International Health Regulations (2005) in Europe. *Euro Surveill* 11:208-11
83. Ryman T, Dietz V, Cairns K. 2008. Too little but not too late: results of a literature review to improve routine immunization programs in developing countries. *BMC Health Services Research* 8:1-11
84. Shih FJ. 1998. Triangulation in nursing research: issues of conceptual clarity and purpose. *J Adv Nurs* 28:631-41
85. Singh V, Madhusudan R, Mohan J. 2011. An evaluation of mobile phone technology use for Integrated Disease Surveillance Project (IDSP) in Andhra Pradesh, India. *ISDS Conference Abstracts*
86. Siswoyo H, Permana M, Larasati RP, Farid J, Suryadi A, Sedyaningsih ER. 2008. EWORS: using a syndromic-based surveillance tool for disease outbreak detection in Indonesia. *BMC Proc* 2
87. Soto G, Araujo-Castillo RV, Neyra J, Fernandez M, Leturia C, et al. 2008. Challenges in the implementation of an electronic surveillance system in a resource-limited setting: Alerta, in Peru. *BMC Proc* 2 Suppl 3:S4

88. Sow I, Alemu W, Nanyunja M, Duale S, Perry H, Gaturuku P. 2010. Trained District Health Personnel and The Performance of Integrated Disease Surveillance in the WHO African Region. *East African Journal of Public Health* 7:16-9
89. Sturtevant JL, Anema A, Brownstein JS. 2007. The new International Health Regulations: considerations for global public health surveillance. *Disaster Med Public Health Prep* 1:117-21
90. Thurmond V. 2001. The Point of Triangulation. *Journal of Nursing Scholarship* 33:253-8
91. Valenciano M, Bergeri I, Jankovic D. 2004. Strengthening early warning function of surveillance in the Republic of Serbia: lessons learned after a year of implementation *Euro Surveill* 9
92. Van Der Meijden MJ, Tange HJ, Troost J, Hasman A. 2003. Determinants of success of inpatient clinical information systems: a literature review. *J Am Med Inform Assoc* 10:235-43
93. Wamala JF, Okot C, Makumbi I, Natseri N, Kisakye A, et al. 2010. Assessment of core capacities for the International Health Regulations (IHR[2005])--Uganda, 2009. *BMC Public Health* 10 Suppl 1:S9
94. Weber IB. 2007. *Evaluation of the Notifiable Disease Surveillance System in Gauteng Province, South Africa*. University of Pretoria. 106 pp.
95. Weintraub I. 2010. *The Role of Grey Literature in the Sciences*. http://library.brooklyn.cuny.edu/access/greyliter.htm
96. Wendler MC. 2001. Triangulation using a meta-matrix. *J Adv Nurs* 35:521-5
97. WHO. 2001. Assessment of the national communicable disease surveillance and response system, Ethiopia. In *Weekly epidemiological record*, pp. 9-16. Geneva
98. WHO. 2003. Implementing integrated disease surveillance and response - Successes, challenges and lessons learned: the Uganda experience (ISDR). In *Weekly epidemiological record*, pp. 229-40. Geneva
99. WHO. 2005. Global consultation on strengthening national capacities for surveillance and control of communicable diseases, World Health Organization, Geneva
100. WHO. 2006. Communicable disease surveillance and response systems - Guide to monitoring and evaluating, World Health Organization
101. WHO. 2006. Communicable Disease Surveillance and Response Systems: A guide to planning, World Health Organization, Geneva
102. WHO, CDC, USAID, SARA, UNFIP. 2003. The Implementation of Integrated Disease Surveillance and Response in the African and Eastern Mediterranean Regions
103. Williams H, Durrheim D, Shretta R. 2004. The process of changing national malaria treatment policy: lessons from country-level studies. *Health Policy and Planning* 19:356-70
104. Williamson GR. 2005. Illustrating triangulation in mixed-methods nursing research. *Nurse Res* 12:7-18
105. Wuhib T, Chorba TL, Davidiants V, Mac Kenzie WR, McNabb SJ. 2002. Assessment of the infectious diseases surveillance system of the Republic of Armenia: an example of surveillance in the Republics of the former Soviet Union. *BMC Public Health* 2:3

106. Zvavamwe S. 2008. Implementing a community-based tuberculosis programme in the Omaheke Region of Namibia: nurses' perceived challenges. *Health SA Gesondheid* 13:54-68